PLANT CELL BIOLOGY AND DEVELOPMENT

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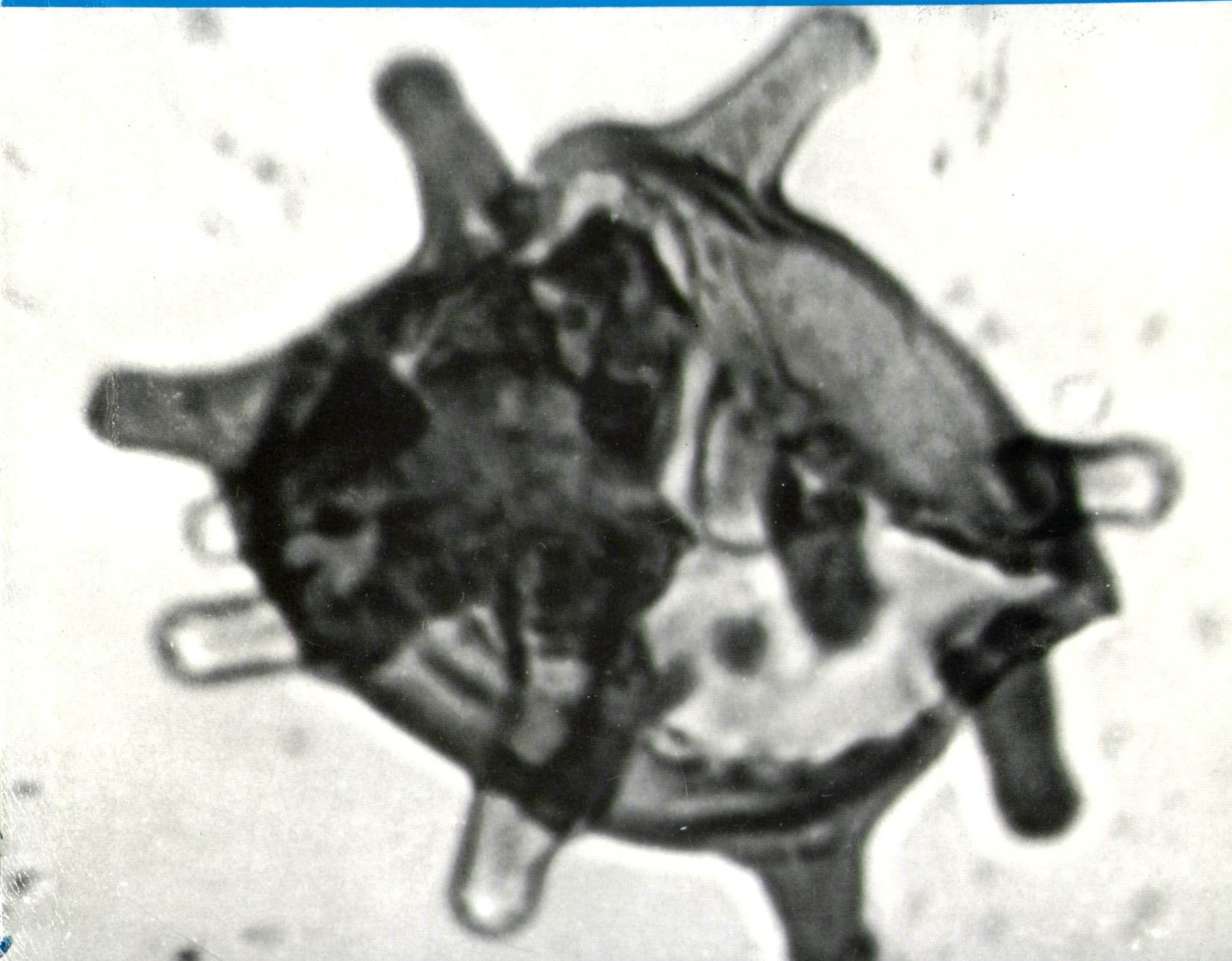

Plant Cell Biology and Development

9

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Contents

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Preface

The 8^{th} volume of Plant Cell Biology and Development published on 3^{rd} April 1997 as it was mentioned previously having for the first time an International Editorial Board. The next volumes will be published at least first part of the year. The distribution was made as follows. In all countries which was enumerated on page 7 of the previous volume at least one copy was mailed. Later an effort was made in order that all libraries and colleagues will receive before long who are in publications exchange with our Laboratory.

Our Laboratory has a new tradition which is on the 21^{st} August 1997, the following persons received the Commemorative Medal of the Laboratory:

Prof. Dr. T. SZEDERKÉNYI: Head of the Department of Mineralogy, Petrography and Geochemistry of the J. A. University for his kind activity for the Laboratory and for the very fruitful joint research programs organisated by both sides.

Dr. S. C. SRIVASTAVA: Assistant Director, Birbal Sahni Institute of Palaeobotany, Lucknow, India has been favoured for the "Commemorative Medal" of the Laboratory, in recognition of his excellence in palaeobotanical research and for the promotion of multidisciplinary science of Palaeobotany on international plane.

Dr. B. S. VENKATACHALA: Emeritus Scientist recognition of his and distinguished contributions to Palynology and Palaeobiology and allied sciences.

A. BORBOLA: University Student was awarded the Laboratory Diploma on the 21 August 1997 on the exclusive reception of the Laboratory. She is helpful very much in the working of programs of the Laboratory and she got remarkables scientific results.

For their financial support in the publication of this volume I would like to say thanks to the following institutions and persons

to the Grant OTKA 1/7 T 014692 and T/9 023208,

to the Scientifical and High-educational Foundation of the Local Government of Szeged,

to the Regional Committee of the Hungarian Academy of Sciences,

to the Faculty of Science of the J. A. University,

to Dr. K. TANDORI and Dr. GY. TELEGDY, members of the Hungarian Academy of Sciences,

to Dr. I. SZALAY Major and Dr. I. FARKAS Town-Councillor of the Local Government of Szeged,

to Prof. Dr. K. VARGA, Dean of the Faculty of Science, J. A. University.

Finally I am obliged to emphasize again, that the position of the Laboratory (head, place) is unchanged based on the agreement of the Rector of the J. A. University (cf. Plant Cell Biology and Development 7, p. 102). Recently at international symposia on Palynology, several excellent scientists asked me it is true that my Laboratory was contracted with another one of the Department of Botany of the J. A. University. This is the reason why that I must reject this information which was published by E-mail from the J. A. University.

Szeged, 30 December, 1997.

M. KEDVES
Head of the Laboratory

1. UPPER CRETACEOUS POLLEN GRAINS FROM EGYPT II.

M. KEDVES

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Abstract

This contribution presents the taxonomy and the occurrences of the following form-genuses: *Cycadopites, Confertisulcites, Clavatipollenites, Liliacidites, Retimonocolpites, Echinoidites, Feugeuripollenites, Granamonocolpites, Psilamonocolpites, Monocolpopollenites, Farafrapollenites, Curvimonocolpites, Aegyptipollenites, Punctilongisulcites, Janducheneipollenites, Gemmazonocolpites, Trichotomosulcites* and *Saadipollenites*. New taxa described herein: *Auritomonosulcati* n. infraturma, *Farafrapollenites ellipsus* n. fgen. et fsp., *F. magnus* n. fsp., *Aegyptipollenites maastrichtiensis* n. fgen. et fsp., *Janducheneipollenites aegypticus* n. fgen. et fsp., *Saadipollenites farafraensis* n. fgen. et fsp., *S. maastrichtiensis* n. fsp., *Psilamonocolpites couperii* n. fsp., *Monocolpopollenites potoniei* n. fsp. *potoniei, M. potoniei* subfsp. *minor* n. subfsp., *Curvimonocolpites rakosii* n. fsp. *Trichotomosulcites couperii* n. fsp., *Retimonocolpites obaensis* subfsp. *aegypticus* n. subfsp., *Feugeuripollenites eocenicus* subfsp. *africanus* n. subfsp.

Key words: Palynology, fossil, *Gymnospermatophyta, Angiospermatophyta,* Upper Cretaceous, Egypt.

SUBTURMA: *MONOCOLPATES* IVERSEN and TROELS-SMITH 1950

Form-genus: *Cycadopites* WODEHOUSE 1933 ex WILSON and WEBSTER 1946

A new diagnosis was published by KRUTZSCH (1970), including a number of synonyms from 1933 through 1966.

1. *Cycadopites minor* (KEDVES 1961) KEDVES 1968, *Cycadaceae* v. *Spadiciflorae* (Plate 1.1., figs. 1,2)

Description: Monosulcate pollen grains with sharpened poles. Furrow asymmetrical, sometimes the exine is plicated parallel to the furrow. Surface scabrate. The exine is 0.3–0.6 μm thick, layered but the infratectal layer is not discernible by light microscope.

Polar axis: 23 μm; 22–29 μm.

Occurrence and frequency in the samples investigated from Egypt: Coniacian-Santonian: Abu Rauwash (70-1-7-1) infrequent, Abu Rauwash (70-1-7-2) infrequent, Duwi Common; Lower Campanian: Duwi frequent; Upper Campanian: Duwi infrequent; Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (6-2-1) common, Farafra (11) infrequent, Kharga (1-39) infrequent, Maestrichtian fm. indet.: Oweina (1) infrequent.

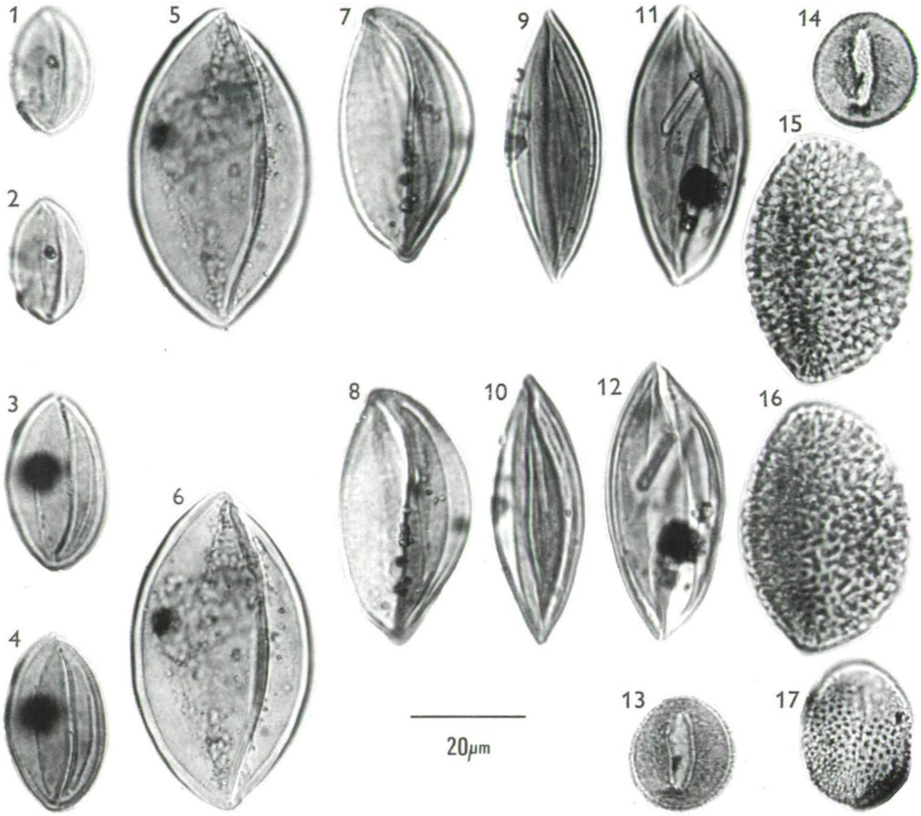

Plate 1.1.

1,2. *Cycadopites minor* (KEDVES 1961) KEDVES 1968, *Cycadaceae* v. *Spadiciflorae*, slide: Farafra-6-2-2-5, cross-table number: 12.2/105.2.
3,4. *Cycadopites fragilis* SINGH 1964, *Cycadaceae*, slide: Abu Minquar-4-3-10, cross-table number: 19.7/101.7.
5,6. *Cycadopites balinkaense* KEDVES 1974, *Cycadaceae, Encephalartos*, slide: Abu Minquar-4-3-9, cross-table number: 12.4/105.7.
7,8. *Cycadopites balinkaense* KEDVES 1974, *Cycadaceae, Encephalartos*, slide: Abu Minquar-4-3-4, cross-table number: 15.7/110.7.
9,10. *Confertisulcites fusiformis* FREDERIKSEN 1973, slide: Abu Minquar-4-3-1, cross-table number: 13.3/109.1.
11,12. *Confertisulcites fusiformis* FREDERIKSEN 1973, slide: Abu Minquar-4-3-4, cross-table number: 17.6/115.5.
13,14. *Clavatipollenites* cf. *rotundus* KEMP 1968, slide: Kharga-1-39-3, cross-table number: 11.1/111.2.
15,16. *Liliacidites barakatii* (HEGEDŰS, KEDVES and PÁRDUTZ 1972) KEDVES 1990, *Liliaceae*, slide: Farafra-6-2-2-1, cross-table number: 14.6/103.2.
17. *Liliacidites variegatus* COUPER 1953, *Liliaceae*, slide: Kharga-1-28-3, cross-table number: 10.1/119.5.

2. *Cycadopites fragilis* SINGH 1964, *Cycadaceae*
(Plate 1.1., figs. 3,4)

Description: Monosulcate pollen grains with slightly sharpened poles. Furrows asymmetrical with very characteristic plicae; sometimes resembling supplementary colpi. Surface scabrate-punctate. The exine is 1-1.2 μm thick, three layered; the three ectexine layers have the same thickness. The fine structure of the infratectal layer is not discernible by light microscope.

Polar axis: 30 μm; 27–38 μm.

Occurrence and frequency in the samples investigated from Egypt: Coniacian-Santonian: Abu Rauwash (70-1-7-1) infrequent, Maestrichtian, Nubia Sandstone: Farafra (6-2-1) infrequent, Abu Minquar (4-3) infrequent, Kharga (1-39) infrequent.

3. *Cycadopites balinkaense* KEDVES 1974, *Cycadaceae, Encephalartos*
(Plate 1.1., figs. 5–8)

Description: Monosulcate pollen grains with sharpened poles. Surface scabrate-punctate. The exine is 1.9–2.2 μm thick, three layered; the tectum is very thick, the infratectal layer is the thinnest; T/I/F = 4-5/1/1.5. Structure is probably alveolar but only small columella-like elements are observable.

Polar axis: 55 μm; 43–56 μm.

Remark: Generally, the exine is thicker and granular at the apices of the specimens of the Eocene layers of Hungary.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Abu Minquar (4-3) infrequent, Kharga (1-39) infrequent.

Form-genus: *Confertisulcites* ANDERSON 1960

These pollen grains are very similar to *Cycadopites*. The fusiform shape and the several plicae serve to distinguish these two form-genera.

1. *Confertisulcites fusiformis* FREDERIKSEN 1973
(Plate 1.1., figs. 9–12)

Description: Monosulcate pollen grains with generally characteristic sharpened poles. Around the furrow there are several plicae that are parallel with the ambitus. Surface smooth, or scabrate. The exine is 0.8–1.2 μm thick, the tectum, infratectal, and foot layer are equal. The fine structure of the infratectal layer is not discernible by the light microscope.

Polar axis: 48 μm; 42–50 μm.

Remark: *Monocolpopollenites banthelui* GRUAS-CAVAGNETTO 1968 is essentially this pollen type.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Abu Minquar (4-3) infrequent.

Form-genus: *Clavatipollenites* COUPER 1958

DOYLE, M. VAN CAMPO and LUGARDON (1975) discussed in detail the taxonomy of these pollen grains. The SEM study of *C.* cf. *hughesii* COUPER 1958 from a Susquehanna Aqueduct sample (Barremian or Aptian) demonstrated that the tectum is perforated or eureticulate. The sulcus membrane is covered with indistinct verrucate elements. A TEM study revealed that there is no endexine.

1. *Clavatipollenites* cf. *rotundus* KEMP 1968
(Plate 1.1., figs. 13,14)

Description: Amb circular or elliptical. Surface finely reticulate, the mesh of the reticuli is 0.4–0.6 μm. The exine is 1.5–1.7 μm thick, the foot layer is the thickest between the ectexine layers; T/I/F = 1/1.5/3. The elements of the infratectal layer are thickened at their ends (pilae). The sulcus is short and does not reach the poles.

Polar axis: 20 μm.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Kharga (1-39) infrequent, Kharga (1-28) infrequent.

Form-genus: *Liliacidites* COUPER 1953

COUPER (1953), p. 56: "Reticulum variable in size, clavate, baculate in optical section." KRUTZSCH (1970), p. 30: "Die, wie oben schon erwähnt, nicht leichte Abgrenzung von *Liliacidites* zu *Arecipites* läβt sich nur durchführen, wenn man nur die gröβeren und gröber reticulaten Vertreter, die in der Tat weniger von *Palmen* als vor allem von *Liliaceen* etc. stammen dürften, bei *Liliacidites* beläβt."

1. *Liliacidites barakatii* (HEGEDŰS, KEDVES and PÁRDUTZ 1972) KEDVES 1990, *Liliaceae*
(Plate 1.1., figs. 15,16)

Description: Monosulcate pollen grains with sharpened apices. Sculpture reticulate, the mesh of the reticuli is 1.5–2.3 μm. Muri width is 1.3–1.8 μm. The exine is 2.2–2.4 μm thick, the tectum is the thickest between the ectexine layers.

Polar axis: 43 μm; 33–46 μm.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) common, Farafra (6-2-1) frequent, Kharga (1-39) common, Kharga (1-28) common, Maestrichtian, fm. indet.: Oweina (1) infrequent.

2. *Liliacidites variegatus* COUPER 1953, *Liliaceae*
(Plate 1.1., fig. 17, plate 1.2., fig. 1)

Description: Monosulcate pollen grains, the sulcus does not reach the poles. Sculpture reticulate, the mesh of the reticuli is 1.5–2.8 μm. The exine is 0.8–1.2 μm thick, the tectum, infratectal layer and the foot layer are equal in thickness.

Polar axis: 26 μm; 23–31 μm.

Remark: Similar form. – FREDERIKSEN (1973), pl. 3, fig. 15,16; *Liliacidites tritus* FREDERIKSEN n. sp. This species seems to be heterogeneous in character. See below *Retimonocolpites noremi* JAN DU CHÊNE and ADEGOKE 1978.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (6-2-1) common, Farafra (11) infrequent, Kharga (1-39) infrequent, Kharga (1-28) infrequent.

Form-genus: *Retimonocolpites* PIERCE 1961

KRUTZSCH (1970), p. 28: "Unterscheidende Merkmale zu *Liliacidites* sind die Größe, die allgemeine Größe des Reticulums und dessen Differenzierung."

As regards the botanical affinities of these pollen grains it is necessary to take into consideration the results of EHLER and SCHILL (1973) on recent *Bromeliaceae* pollen grains. The following data are worth mentioning in respect to our data: *Tillandsia ixioides* GRISEB., *T. tenuifolia* L., *Dychia choristaminea* L. B. SMITH, *Navia crispa* L. B. SMITH.

1. *Retimonocolpites vaneendenburgi* (GERMERAAD, HOPPING and MULLER 1968) n. comb.
(Plate 1.2., figs. 2–5)

Syn.: 1968 *Longapertites vaneendenburgi* GERMERAAD, HOPPING and MULLER, p. 298, pl. 5, fig. 4.

Description: Monosulcate pollen grains, with sharpened apices. Furrow asymmetrical and reaching the poles. Surface finely reticulate, the lumen and the muri width are generally equal; 0.5–0.8 μm. The amb of the lumen is polygonal. The exine is 0.5–0.7 μm thick, the infratectal layer is the thickest between the ectexine layers, T/I/F = 1/2/1.

Polar axis: 52 μm; 44–53 μm.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (6-2-1) infrequent.

2. *Retimonocolpites abeokutaensis* JAN DU CHÊNE 1977
(Plate 1.2., figs. 6,7)

Description: Monosulcate pollen grains with ellipsoidal amb or with sharpened apices. Furrow asymmetrical, long but in general does not reach the apices. Surface finely reticulate, the mesh of the reticuli is 0.8–1.2 μm, the muri is 0.5 μm in width. Exine is 1–1.3 μm thick, the infratectal layer is the thickest between the ectexine layers, T/I/F = 1/1.5/1. The infratectal layer is columellar.

Polar axis: 38 μm; 32–40 μm.

Remarks: The specimens from Egypt are a little smaller than those of Senegal. The lumina of the reticulum of *R. splendidus* GONZÁLEZ GUZMÁN 1967 are larger 0.5–1 μm, and the polar axis is 49–55 μm.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (6-2-1) infrequent.

3. *Retimonocolpites obaensis* JAN DU CHÊNE, ONYIKE and SOWUNMI 1978 subfsp. *aegypticus* n. subfsp.
(Plate 1.2., figs. 8–11)

Syn.: 1965 *Monocolpopollenites* sp., JARDINÉ and MAGLOIRE, p. 212, pl. 9, figs. 5–8; Campanian – L. Senonian, Ivory Coast; L. Senonian, Senegal.


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Plate 1.2.

Diagnosis: Monosulcate pollen grains, sulcus asymmetrical and does not reach the apices. Surface very finely reticulate, the mesh of the reticuli is 0.2–0.3 μm; muri width is 0.2 μm. The exine is 0.5–0.7 μm thick; the infratectal layer is a little thicker than the tectum and the foot layer, T/I/F = 1/1.5/1.

Polar axis: 31 μm; 26–35 μm.

Subfsp. type: Plate 1.2., figs. 8,9, slide: Farafra-6-2-2-1, cross-table number: 18.8/109.7.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.

Stratum typicum: clayey brown coal.

Derivatio nominis: From Egypt.

Differential diagnosis: *R. obaensis* JAN DU CHÊNE, ONYIKE and SOWUNMI 1978 *obaensis* is larger; 34–45 μm, diameter of the muri 0.5–0.7 μm, those of the lumen, 0.8–1.4 μm, the exine is 1.1–1.5 μm thick. *R. noremi* JAN DU CHÊNE and ADEGOKE 1978a is smaller (23 μm).

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) common, Farafra (6-2-1) frequent, Farafra (11) infrequent, Kharga (1-39) infrequent, Kharga (1-28) infrequent.

Plate 1.2.

1. *Liliacidites variegatus* COUPER 1953, *Liliaceae*, slide: Kharga-1-28-3, cross-table number: 10.1/119.5.

2,3. *Retimonocolpites vaneendenburgi* (GERMERAAD, HOPPING and MULLER 1968) n. comb., slide: Farafra-6-2-2-1, cross-table number: 8.3/115.8.

4,5. *Retimonocolpites vaneendenburgi* (GERMERAAD, HOPPING and MULLER 1968) n. comb., slide: Farafra-6-2-1-5, cross-table number: 19.0/106.2.

6,7. *Retimonocolpites abeokutaensis* JAN DU CHÊNE 1977, slide: Farafra-6-2-2-1, cross-table number: 13.6/101.4.

8,9. *Retimonocolpites obaensis* JAN DU CHÊNE, ONYIKE and SOWUNMI 1978 subfsp. *aegypticus* n. subfsp., slide: Farafra-6-2-2-1, cross-table number: 18.8/109.7.

10,11. *Retimonocolpites obaensis* JAN DU CHÊNE, ONYIKE and SOWUNMI 1978 subfsp. *aegypticus* n. subfsp., slide: Farafra-6-2-2-1, cross-table number: 8.1/109.7.

12,13. *Retimonocolpites noremi* JAN DU CHÊNE and ADEGOKE 1978a, cf. *Palmae*, slide: Farafra-6-2-2-3, cross-table number: 16.8/112.6.

14,15. *Retimonocolpites noremi* JAN DU CHÊNE and ADEGOKE 1978a, cf. *Palmae*, slide: Farafra-6-2-1-7, cross-table number: 3.8/111.8.

16,17. *Echinoidites* fsp., slide: Farafra-6-2-2-10, cross-table number: 13.4/102.9.

18,19. *Feugueuripollenites eocenicus* (KEDVES 1965) KEDVES 1968 subfsp. *africanus* n. subfsp., *Palmae*, slide: Farafra-6-2-1-5, cross-table number: 11.6/107.7.

20,21. *Feugueripollenites eocenicus* (KEDVES 1965) KEDVES 1968 subfsp. *africanus* n. subfsp., *Palmae*, slide: Farafra-6-2-1-5, cross-table number: 11.6/107.7.

22,23. *Granamonocolpites* fsp., *Palmae*, slide: Farafra-6-2-2-1, cross-table number: 17.6/102.3.

24,25. *Psilamonocolpites couperii* n. fsp., *Palmae*, slide: Kharga-1-39-4, cross-table number: 13.6/108.4.

26,27. *Monocolpopollenites potoniei* n. fsp. subfsp. *potoniei*, slide: Farafra-6-2-2-5, cross-table number: 9.2/115.8.

28,29. *Monocolpopollenites potoniei* n. fsp. subfsp. *potoniei*, slide: Farafra-6-2-2-4, cross-table number: 12.3/108.3.

30,31. *Monocolpopollenites potoniei* n. fsp. subfsp. *minor* n. subfsp., slide: Farafra-6-2-2-11, cross-table number: 17.7/106.5.

32,33. *Farafrapollenites ellipsus* n. fgen. et fsp., slide: Farafra-6-2-1-4, cross-table number: 5.3/104.2.

34,35. *Farafrapollenites ellipsus* n. fgen. et fsp., slide: Farafra-6-2-1-6, cross-table number: 4.1/109.7.

36,37. *Farafrapollenites magnus* n. fgen. et fsp., slide: Farafra-6-2-1-10, cross-table number: 14.7/103.4.

38. *Curvimonocolpites rakosii* n. fsp., slide: Abu Minquar-4-3-4, cross-table number: 10.3/113.4.

4. *Retimonocolpites noremi* JAN DU CHÊNE and ADEGOKE 1978a, cf. *Palmae*
(Plate 1.2., figs. 12–15)

Description: Monosulcate pollen grains with sharpened apices. Sulcus, in general asymmetrical, and reaching the poles. Surface finely reticulate, the mesh of the reticuli is 0.2–0.3 μm, the muri are 0.2 μm in width. The exine is 0.7–1 μm thick, T/I/F = 1.5/2/1.

Polar axis: 25 μm; 22–29 μm.

Remarks: The specimens from Egypt are a little larger than those specimens from the Paleocene layers of Nigeria. *Liliacidites tritus* FREDERIKSEN 1973 (Pl. 3, figs. 13,14) is similar.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (6-2-1) infrequent, Abu Minquar (4-3) infrequent, Kharga (1-39) common, Kharga (1-28) common.

Form-genus: *Echinoidites* GONZÁLEZ GUZMÁN 1967

This form-genus was described from the Eocene layers of Colombia. The echinate sculptural elements are sometimes slightly clavate. Therefore there is a certain similarity with the *Grimsdalea* types of JAN DU CHÊNE, ONYIKE and SOWUNMI (1978) from the Eocene layers of Nigeria. However *Grimsdalea* GERMERAAD, HOPPING and MULLER 1968 from Trinidad is a non-aperturate pollen type.

1. *Echinoidites* fsp.
(Plate 1.2., figs. 16,17)

Description: Surface smooth the exine is 0.5–0.8 μm thick, the infratectal layer is a little thicker than the tectum and the foot layer. Structure finely baculate. The sculptural elements are 8–12 μm long, sometimes slightly thickened at their ends so this sculpture is similar to those of *Grimsdalea* GERMERAAD, HOPPING and MULLER 1968, but the pollen grains of the later mentioned form-genus are inaperturate.

Polar axis: 49 μm; smaller that the specimen of GONZÁLEZ GUZMÁN (1967).

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent.

Form-genus: *Feugueuripollenites* KEDVES 1968

Relatively small monosulcate pollen grains, ornamented with short spinae.

1. *Feugueuripollenites eocenicus* (KEDVES 1965) KEDVES 1968 subfsp. *africanus* n. subfsp.
(Plate 1.2., figs. 18–21)

Diagnosis: Monosulcate pollen grain, sulcus asymmetric and reach the poles. Surface smooth to scabrate, sculptured with echinate sculptural elements which are 2–2.6 μm long. The exine is 0.5–0.6 μm thick, the infratectal layer is a little thicker than the tectum and the foot layer, T/I/F = 1/1.5/1.

Polar axis: 23 μm; 19–24 μm.

Subfsp. type: Plate 1.2., figs. 18,19, slide: Farafra-6-2-1-5, cross-table number: 11.6/107.7.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.

Stratum typicum: clay.
Derivatio nominis: From Africa.
Differential diagnosis: *F. eocenicus* (KEDVES 1965) KEDVES 1968 *eocenicus* is larger (20–38 μm) and the exine is 1.5–2 μm thick. The sculptural elements are 1–2 μm long.
Remarks: Recent taxa, with similar pollen grains: *Astelis cunninghamii* HOOK (COUPER, 1960, pl. 9, fig. 8), *Didymosperma porphyrocarpa* WENDL. (KEDVES, 1980, Plate 4, figs. 2,3).
Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) common, Farafra (6-2-1) common, Farafra (11) infrequent.

Form-genus: *Granamonocolpites* PIERCE 1961

Monosulcate pollen grains, sculpture granulate.

1. *Granamonocolpites* fsp., *Palmae*
   (Plate 1.2., figs. 22,23)

Description: Monosulcate pollen grains with sharpened apices. The sulcus is long and reaches the poles. The surface is granulate, sometimes the sculptural elements anastomosent to rugulate ornamentation. Size of the ornamental elements is 0.4–1.5 μm. The exine is 0.5–0.7 μm thick, the infratectal layer is a little thicker than the tectum and the foot layer, T/I/F = 1/1.5/1.
Polar axis: 23 μm; 32–48 μm.
Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Kharga (1-39) infrequent.

Form-genus: *Psilamonocolpites* VAN DER HAMMEN and GARCIA MUTIS 1965

Psilate, monocolpate pollen grains.
Psilamonocolpites MATHUR 1966, p. 40, pl. 1, fig. 15 is junior homonym of *Ps.* VAN DER HAMMEN and GARCIA MUTIS 1965, cf. JANSONIUS and HILLS, 2224.

1. *Psilamonocolpites couperii* n. fsp.
   (Plate 1.2., figs. 24,25)

Diagnosis: Monosulcate pollen grains, the sulcus is asymmetrical, long, but do not reach the poles. Surface smooth. The exine is 0.6–0.9 μm thick, the tectum, infratectal layer and the foot layer are of equal thickness. Structure finely intrabaculate.
Polar axis: 20 μm; 18–23 μm.
Holotype: Plate 1.2., figs. 24,25, slide: Kharga-1-39-4, cross-table number: 13.6/108.4.
Locus typicus: Kharga, Maestrichtian, Nubia Sandstone.
Stratum typicum: clay.
Derivatio nominis: In honour of Dr. R. A. COUPER.
Differential diagnosis: *Psilamonocolpites* (= *Monosulcites*) *otagoensis* COUPER 1960 is larger, and the exine is 1.5–2 μm thick.
Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Kharga (1-39) infrequent.

Form-genus: *Monocolpopollenites* PFLUG 1953, in THOMSON and PFLUG 1953

A number of species were closed in this form-genus, but it is necessary to emphasize that the sulcus of this genus does not reach the poles (cf. the original paper of R. POTONIÉ 1934, and KRUTZSCH 1970). The pollen grains of *Rectosulcites* ANDERSON 1960 have broad and relatively short furrows, but these furrows are newer broader at their ends, as opposed to those of *Monocolpopollenites*. The pollen grain of JAN DU CHÊNE, DE KLASZ and ARCHIBONG (1978) from the Cretaceous layers of Senegal (pl. 3, fig. 12) belongs to this form-genus. Similarly *Psilamonocolpites minor* JAN DU CHÊNE and ADEGOKE 1978b (in JAN DU CHÊNE, ADEGOKE, ADEDIRAN and PETTERS) from the Maestrichtian of Nigeria also belongs to this genus.

1.1. *Monocolpopollenites potoniei* n. fsp. subfsp. *potoniei*
(Plate 1.2., figs. 26–29)

Diagnosis: Amb circular or elliptical. Surface scabrate-punctate. The exine is 0.4–0.5 µm thick, its structure is not discernible by the light microscope. Sulcus is in general asymmetric and does not reach the poles. Around the sulcus margin there are exine thick rings. The sulcus is 0.8–1.2 µm wide in the middle and 2.5–5 µm at their ends.

Polar axis: 16 µm; 16–25 µm.

Holotype: Plate 1.2., figs. 26,27, slide: Farafra-6-2-2-5, cross-table number: 9.2/115.8.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.

Stratum typicum: clayey brown coal.

Derivatio nominis: In memoriam of Prof. Dr. R. POTONIÉ, who first described this morphological type of palm pollen grain from the pre-Quaternary sediments.

Differential diagnosis: The ambitus, the very thin pollen wall and the peculiar sulcus morphology distinguish this species from *M. tranquillus* (R. POTONIÉ 1934) THOMSON and PFLUG 1953, see the emended diagnosis of NICHOLS, AMES and TRAVERSE (1973), p. 251, *M. tranquilloides* NICHOLS, AMES and TRAVERSE 1973 is larger and the ambitus is more elongated than that of *M. potoniei.*

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) common, Farafra (6-2-1) infrequent, Farafra (11) infrequent.

1.2. *Monocolpopollenites potoniei* n. fsp. subfsp. *minor* n. subfsp.
(Plate 1.2., figs. 30,31)

Diagnosis: Amb generally elliptical. The sulcus is 0.7–1.3 µm wide in the middle and 1.5–3 µm at the ends.

Diameter: 12 µm; 10–14 µm.

Subfsp. type: Plate 1.2., figs. 30,31, slide: Farafra-6-2-2-11, cross-table number: 17.7/106.5.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.

Stratum typicum: clayey brown coal.

Derivatio nominis: From its smaller size.

Differential diagnosis: The smaller size distinguish it from the typical forms of this form-species.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (11) infrequent.

Form-genus: *Farafrapollenites* n. fgen.
Form-genus type: *Farafrapollenites ellipsus* n. fgen. et fsp.
(Plate 1.2., figs. 32–35)

Diagnosis: Monosulcate pollen grains, the sulcus does not reach the poles and are narrower in the middle that at the ends. Around the sulcus, the exine is characteristically sculptured – verrucate, sometimes rugulate. The extra-apertural exine is smooth or scabrate.

Form-genus type: Plate 1.2., figs. 32,33, slide: Farafra-6-2-1-4, cross-table number: 5.3/104.2.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.

Stratum typicum: clay.

Derivatio nominis: From Farafra, from the locality type.

Differential diagnosis: The sculptured sulcus margin clearly separates this genus from *Monocolpopollenites* PFLUG 1953.

Remarks: *Clavatipollenites incisus* KHLOVONA 1976 has a similar sculptured zone around the sulcus, but its sculpture separates it from the described new form-genus. On the other hand it seems that KHLONOVA's (1976) species is quite different from the earlier described species of *Clavatipollenites* COUPER 1958.

1. *Farafrapollenites ellipsus* n. fsp.
(Plate 1.2., figs. 32–35)

Diagnosis: Amb ellipsoidal, surface scabrate. The exine is 0.5–0.8 μm thick, the tectum, infratectum, and the foot layer are of equal thickness. The fine structure of the infratectal layer is not discernible by optical microscope. The sulcus is long but does not reach the poles. Around the sulcus the verrucae are 1–1.5 μm in basal diameter, sometimes anastomosent. The sulcus is 2-3.5 μm wide at the ends.

Polar axis: 20 μm; 18–24 μm.

Holotype, locus typicus, stratum typicum, see previously.

Derivatio nominis: From the form of the ambitus.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (6-2-1) common.

2. *Farafrapollenites magnus* n. fsp.
(Plate 1.2., figs. 36,37)

Diagnosis: Amb circular or elliptical. Surface smooth or scabrate. The exine is 0.6–0.8 μm thick, the three layers of the ectexine are of equal thickness. The fine structure of the infratectal layer is not discernible by light microscope, probably granular. The sulcus is long but does not reach the poles; the widening at the ends is 1.2–1.5 μm. Around the sulcus, the sculptured zone is 2.5–4.5 μm wide, granulate-verrucate, the ornamental elements have 1–1.5 μm basal diameter.

Polar axis: 28 μm; 26–32 μm.

Holotype: Plate 1.2., figs. 36,37, slide: Farafra-6-2-1-10, cross-table number: 14.7/103.4.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.
Stratum typicum: clay.
Derivatio nominis: From its relatively large size.
Differential diagnosis: The larger size, the moderately hollowed sulcus and the larger sculptured zone around the sulcus separate this species from *F. ellipsus* n. fgen. et fsp.
Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (6-2-1) common.

Form-genus: *Curvimonocolpites* LEIDELMEYER 1966 here emended.

Emended diagnosis: Asymmetrical, monosulcate pollen grains. Surface psilate, scabrate, finely sculptured or perforated. The aperture is along the concave side of the pollen grain.
Remarks: The data of L. RÁKOSI (1973, 1977) from the Eocene layers of Hungary (*C. inornatus* LEIDELM. 1966) is worth mentioning.

1. *Curvimonocolpites rakosii* n. fsp.
(Plate 1.2., fig. 38, plate 1.3., figs. 1–3)

Diagnosis: Amb characteristic asymmetrical, half ellipse. Surface finely perforated, the diameter of the perforations is about 0.2 μm. Inter-apertural exine is 0.4–0.6 μm thick, its structure is not discernible by optical microscope. Near the sulcus the exine is 1–1.5 μm thick with characteristic structure, the tectum, infratectum, and the foot layer are equal in thickness. Structure finely intrabaculate.
Polar axis: 42 μm; 33–46 μm.
Holotype: Plate 1.2., fig. 38, plate 1.3., fig. 1, slide: Abu Minquar-4-3-4; cross-table number: 10.3/113.4.
Locus typicus: Abu Minquar, Maestrichtian, Nubia Sandstone.
Stratum typicum: coaly clay.
Derivatio nominis: In honour of Dr. L. RÁKOSI, excellent investigator of the Lower Tertiary sporomorphs.
Differential diagnosis: The perforate tectum of *C. rakosii* n. fsp. serves to clearly separate it from *C. inornatus* LEIDELM. 1966, which has a psilate to scabrate, imperforate tectum.
Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Abu Minquar (4-3) infrequent.

Form-genus: *Aegyptipollenites* n. fgen.
Form-genus type: *Aegyptipollenites maastrichtiensis* n. fgen. et fsp.
(Plate 1.3., figs. 4–7)

Diagnosis: Monocolpate pollen grains with equatorial circular band. Surface smooth or finely sculptured; the colpal margin is generally ornamented with characteristic sculptural elements.
Form-genus type: Plate 1.3., figs. 4,5, slide: Abu Minquar-4-3-7, cross-table number: 16.2/104.9.
Locus typicus: Abu Minquar, Maestrichtian, Nubia Sandstone.
Stratum typicum: coaly clay.
Derivatio nominis: From Egypt.

Differential diagnosis: The lack of medial horns distinguished this genus from *Galeacornea* STOVER 1963.

Remarks: The new genus may be an evolved form of the Middle Cretaceous "*Galeacornea* type" microfossils.

1. *Aegyptipollenites maastrichtiensis* n. fsp.
   (Plate 1.3., figs. 4–7)

Syn: 1995 *Proxapertites africanus* KDS. nom. nud., JELEN, KEDVES, SKABERNE, BREZIGAR, BUSER, CIMERMAN, DROBNE, MONOSTORI, PAVLOVEC and PAVŠIČ, p. 22, plate 2.3., figs. 13, 14.

Diagnosis: Amb elliptical, sometimes with slightly sharpened apices. The colpus reach the apices, the sculpture of the colpal margin is verrucate or rugulate, the size of the ornamental elements is 1.5–2.2 µm. Near the colpus, the exine is granulate, the extra-apertural exine is smooth or scabrate and 2–3 µm thick; in the germinal region there is characteristic intrabaculate structure; T/I/F = 2/1/2. The extra-apertural exine is 1 µm thick generally, and its structure is not clearly discernible by light microscope. The equatorial circular band is 3–5 µm thick, its exine is also thick.

Diameter: 36 µm; 28–40 µm.

Holotype, locus typicus, stratum typicum see previously.

Derivatio nominis: From its geological age.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Abu Minquar (4-3) common.

Form-genus: *Punctilongisulcites* KRUTZSCH 1970

Longisulcate pollen grains, surface punctate, granulate, finely echinate or verrucate.

1. *Punctilongisulcites* fsp.
   (Plate 1.3., figs. 8,9)

Description: Amb ellipsoidal. Sculpture echinate, the sculptural elements are 1–1.2 µm long, and thickened at their base. Exine is 0.6–0.8 µm, the infratectal layer is a little thicker than the outer and the inner ectexine layer. Structure is not well discernible by light microscope; probably infrabaculate. The sulcus is long, on the shorter side is 1/3 of the polar axis.

Polar axis: 28 µm.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-1) infrequent.

Form-genus: *Janducheneipollenites* n. fgen.

Form-genus type: *Janducheneipollenites aegypticus* n. fgen. et fsp.
(Plate 1.3., figs. 10–15)

Diagnosis: Zonosulcate pollen grains, surface smooth or scabrate. Around the sulcus there is a zone with ornamental elements, but this is a pseudosculpture as a result of the tectum reduction. This is similar to granular or verrucate ornamentation.

Form-genus type: Plate 1.3., figs. 10,11, slide: Farafra-6-2-2-8, cross-table number: 12.5/116.3.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.

Stratum typicum: clayey brown coal.

Derivatio nominis: In honour of Dr. R. JAN DU CHÊNE, excellent investigator of the fossil sporomorphs of Africa.

Differential diagnosis: The new genus is separated from *Gemmazonocolpites* JAN DU CHÊNE 1977 by the pseudosculptured zone around the sulcus. The form-genus described by JAN DU CHÊNE (1977) has a gemmate sculpture around the germinal area.

1. *Janducheneipollenites aegypticus* n. fsp.
   (Plate 1.3., figs. 10–15)

Diagnosis: Amb ellipsoidal. Surface scabrate. The exine is 0.6–0.8 μm thick, the tectum, infratectum and the foot layer are of equal thickness, T/I/F = 1/1/1. The structure is not clearly discernible by optical microscope. The pseudosculptured zone around the furrow is 4–6 μm, the elements are 0.5 μm in diameter and its form is globular.

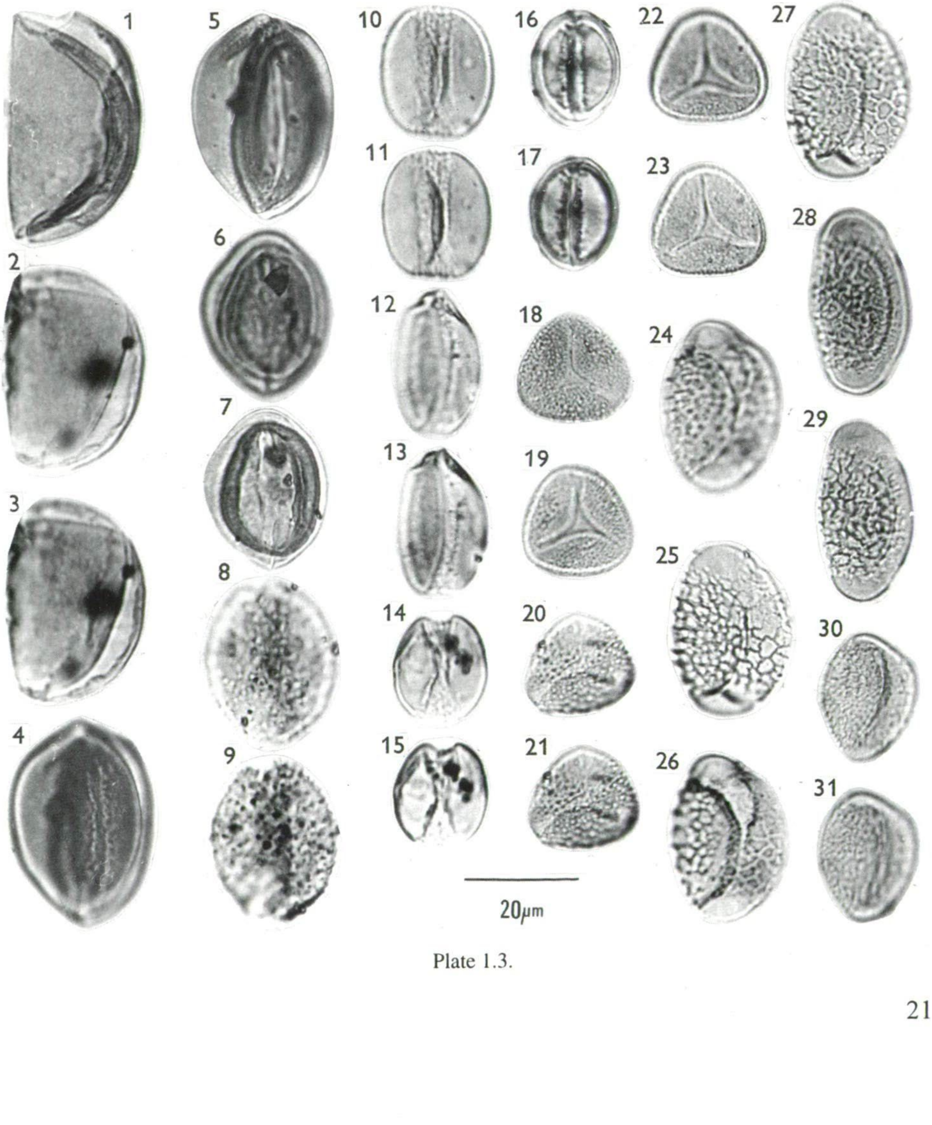

Plate 1.3.

Diameter: 21 µm; 18–27 µm.

Holotype, locus typicus, stratum typicum see at the fgen. diagnosis.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) infrequent, Farafra (6-2-1) infrequent, Farafra (11) infrequent, Kharga (1-39) infrequent.

Form-genus: *Gemmazonocolpites* JAN DU CHÊNE 1977

Diagnosis – JANSONIUS and HILLS, 3466: "Pollen grain with one encircling equatorial sulcus, with a scabrate sculpture except a large band with gemmae. This band seems to cover the equatorial sulcus."

1. *Gemmazonocolpites spheroidites* (JARDINÉ and MAGLOIRE 1965) n. comb.
   (Plate 1.3., figs. 16,17)

Syn.: 1965 *Monocolpopollenites spheroidites* JARDINÉ and MAGLOIRE, p. 211, 212, pl. 8, figs. 27–30.

Description: Zonosulcate pollen grains. Surface scabrate. The exine is 2–3 µm thick, the nexine is the thickest between the exine layers; T/I/N = 1/1/3-4. The structure is finely intrabaculate. Around the sulcus it is about 1–1.5 µm wide thickening and its margin is ornamented with globular elements, 0.5–1 µm in diameter.

Polar axis: 20 µm.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-1) infrequent.

SUBTURMA: *TRICHOTOMOSULCATES* ERDTMAN 1945

Plate 1.3.

1.	*Curvimonocolpites rakosii* n. fsp., slide: Abu Minquar-4-3-4, cross-table number: 10.3/113.4.
2,3.	*Curvimonocolpites rakosii* n. fsp., slide: Abu Minquar-4-3-3, cross-table number: 5.0/105.6.
4,5.	*Aegyptipollenites maastrichtiensis* n. fgen. et fsp., slide: Abu Minquar-4-3-7, cross-table number: 16.2/104.9.
6,7.	*Aegyptipollenites maastrichtiensis* n. fgen. et fsp., slide: Abu Minquar-4-3-7, cross-table number: 5.6/107.2.
8,9.	*Punctilongisculcites* fsp., slide: Farafra-6-2-1-9, cross-table number: 9.6/116.6.
10,11.	*Janducheneipollenites aegypticus* n. fgen. et fsp., slide: Farafra-6-2-2-8, cross-table number: 12.5/116.3.
12,13.	*Janducheneipollenites aegypticus* n. fgen. et fsp., slide: Farafra-6-2-1-6, cross-table number: 3.7/107.2.
14,15.	*Janducheneipollenites aegypticus* n. fgen. et fsp., slide: Farafra-6-2-2-8, cross-table number: 9.1/106.2.
16,17.	*Gemmazonocolpites sphaeroidites* (JARDINÉ and MAGLOIRE 1965) n. comb., slide: Farafra-6-2-1-8, cross-table number: 6.4/115.6.
18,19.	*Trichotomosulcites couperii* n. fsp., *Palmae*, slide: Farafra-6-2-2-1, cross-table number: 8.4/105.5.
20,21.	*Trichotomosulcites couperii* n. fsp., *Palmae*, slide: Farafra-6-2-2-1, cross-table number: 19.8/115.8.
22,23.	*Trichotomosulcites couperii* n. fsp., *Palmae*, slide: Farafra-6-2-2-1, cross-table number: 13.8/104.1.
24,25.	*Saadipollenites farafraensis* n. fgen. et fsp., slide: Farafra-11-1, cross-table number: 11.2/112.8.
26,27.	*Saadipollenites farafraensis* n. fgen. et fsp., slide: Farafra-6-2-2-1, cross-table number: 5.6/113.1.
28,29.	*Saadipollenites farafraensis* n. fgen. et fsp., slide: Farafra-6-2-2-1, cross-table number: 9.3/116.4.
30,31.	*Saadipollenites maastrichtiensis* n. fgen. et fsp., slide: Farafra-6-2-2-1, cross-table number: 13.7/116.9.

Form-genus: *Trichotomosulcites* ERDTMAN 1945 ex COUPER 1953

The trichotomosulcate feature is definitive and characteristic for this genus. However it must be emphasized that, based on the results of a study of recent *palm* pollen grains, there are several species which exhibit both monosulcate and trichotomosulcate forms. Sometimes this is a characteristic feature of a species. Therefore this form-genus is somewhat problematical.

1. *Trichotomosulcites couperii* n. fsp.
   (Plate 1.3., figs. 18–23)

Diagnosis: Trichotomosulcate pollen grains, the branches of the sulcus do not reach the equator. Sculpture reticulate, the mesh of the reticuli is 0.3–0.6 μm, muri width, 0.3–0.4 μm. The exine is 0.7 μm thick, the infratectum is thicker than the tectum or the foot layer, T/I/F = 1/1.5/1.

Diameter: 20 μm; 17–23 μm.

Holotype: Plate 1.3., figs. 18,19, slide: Farafra-6-2-2-1, cross-table number: 8.4/105.5.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.

Stratum typicum: clayey brown coal.

Derivatio nominis: In honour of Dr. R. A. COUPER excellent investigator of the pre-Quaternary sporomorphs.

Differential diagnosis: *T. subgranulatus* COUPER 1953 is finely granular – psilate, size: 27–35 μm. *T. waronuiensis* COUPER 1953 is sub-verrucate, size: 31–35 μm. *T. antiquus* KRUTZSCH and LENK 1969 is reticulate–foveolate, lumina of the reticulum are 0.5–2 μm, size: 32–36 μm. In this way the larger size clearly separates it from *T. couperii* n. fsp. *T. ornatus* BOLTENHAGEN 1976, form the Senonian of Gabon, is reticulate. The mesh of the reticulum is 0.5–5 μm. The large lumina of the reticulum are a very good feature for distinction. The surface of *T. laevigatus* BOLTENHAGEN 1976 is smooth.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) common, Farafra (6-2-1) infrequent.

INFRATURMA: *AURITOMONOSULCATI* n. infraturma

Monosulcate pollen grains, with sculptured, generally reticulate surface. The poles are finely or unsculptured, or with appendices.

Form-genus: *Saadipollenites* n. fgen.
Form-genus type: *Saadipollenites farafraensis* n. fgen. et fsp.
(Plate 1.3., figs. 24–29)

Diagnosis: Monosulcate pollen grains, the surface reticulate. The apices are smooth and rounded, forming a pseudoauricula, its wall consists only of a foot layer.

Form-genus type: Plate 1.3., figs. 24,25, slide: Farafra-11-1, cross-table number: 11.2/112.8.

Stratum typicum: clay.

Derivatio nominis: In honour of Prof. Dr. S. I. SAAD, pioneer of palynological researches in Egypt.

Differential diagnosis: This form-genus must be compared with the monosulcate, auriculate pollen grains. The form-genus *Auriculiidites* was described by ELSIK (1964) from the Upper Cretaceous (Campanian) Vivian Formation of Peru. BELSKY, BOLTENHAGEN and POTONIÉ (1965) published the new genus *Pediculisporis* from the Upper Cretaceous, probably Santonian layers, of Gabon. Later, BOLTENHAGEN (1967) established the fact that *Pediculisporis* is synonymous with *Auriculiidites*, and he emended this latter mentioned genus. ELSIK and THANIKAIMONI (1970) emended the form-genus *Auriculiidites* and compared *Auriculiidites reticulatus* with *Bomarea lyncina* HERB. (*Amaryllidaceae*). ELSIK (1973) described *A. paleocenicus* from Alaska, associated with *Aquilapollenites* and *Pistillipollenites*. ELSIK (1974) reviewed the knowledge of the fossil auriculate pollen grains and introduced the form-genus *Chlonovaia*, which is tricolpate, auriculate; the form-genus type was described by KHLONOVA (1966) as *Auriculiidites sibiricus*. The validation of *Chlonovaia* was published later by ELSIK (1976). Concerning *Auriculiidites* (ELSIK 1964) ELSIK and THANIKAIMONI 1970, the following comments were published: ELSIK 1974, p. 525: "Includes fossil monosulcate, reticulate pollen with "filled" auriculae in contrast to *Pediculisporis*, which has hollow auriculae." In comparison with the described new form-genus we emphasize the following: *Chlonovaia* is tricolporate, the bases of the auriculae of *Pediculisporis* are narrow (never found in our specimens), and the "filled" auriculae of *Auriculiidites* separates it from *Saadipollenites* n. fgen. There is some morphological similarity of our new form-genus with *Liliacidites inaequalis* SINGH 1971, from the Lower Cretaceous layers of Alberta, but the apices of these pollen grains are not smooth.

1. *Saadipollenites farafraensis* n. fsp.
(Plate 1.3., figs. 24–29)

Diagnosis: Monosulcate pollen grains, the sulcus asymmetric. Sculpture reticulate; in the middle of the pollen grain the mesh of the reticuli is 3–5 µm; on the border of the sculptured part and the pseudo-auricula is 0.3–0.4 µm. Muri width about 0.4–0.6 µm. The exine is 0.6–0.8 µm thick, the three ectexine layers are of identical thickness. The sulcus margin is smooth, in the middle of the pollen it is 2.5–3 µm and 0.5 µm wide near the apices. The smooth apex (pseudo-auricula) is 3–5 µm high, and 8–12 µm wide.

Polar axis: 30 µm; 23–32 µm.

Holotype, locus typicus, stratum typicum see previously.

Derivatio nominis: From Farafra.

Occurrence and frequency in the samples investigated from Egypt: Maestrichtian, Nubia Sandstone: Farafra (6-2-2) common, Farafra (6-2-1) infrequent, Farafra (11) infrequent.

2. *Saadipollenites maastrichtiensis* n. fsp.
(Plate 1.3., figs. 30,31)

Diagnosis: Monosulcate, reticulate pollen grains. The mesh of the reticuli is 0.6–1.1 µm, muri width 0.4 µm. The exine is 0.5–0.7 µm thick, the three ectexine layers are of the same thickness. The smooth colpus margin is 1.2–1.6 µm wide. The smooth apex is 2–3 µm high, and 5–7 µm wide.

Polar axis: 22 µm; 20–28 µm.

Holotype: Plate 1.3., figs. 30,31, slide: Farafra-6-2-2-1, cross-table number: 13.7/116.9.

Locus typicus: Farafra, Maestrichtian, Nubia Sandstone.

Stratum typicum: clayey brown coal.

Derivatio nominis: From the geological age of the holotype.

Differential diagnosis: The finer reticulate sculpture separates well this species from *S. farafraensis* n. fsp. It is a certain similarity with *Auriculiidites palaeocenicus* ELSIK 1973, but as it was emphasized previously, *Auriculiidites* have "filled" auriculae (ELSIK, 1974).

Remark. – The slides are deposited in the Cell Biological and Evolutionary Micropaleontological Laboratory of the Dept. of Botany of the J. A. University, Szeged, Hungary.

To be continued

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2. ETUDES PALYNOLOGIQUES DES COUCHES DU TERTIAIRE INFÉRIEUR DE LA RÉGION PARISIENNE. IX.

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Sommaire

Les grains de pollen présentés dans cette étude appartiennent aux genres de forme suivants: *Cupuliferoidaepollenites, Scabratricolpites, Quercoidites, Tricolpites, Retitricolpites, Striatopollis, Pistillipollenites, Aesculiidites, Psilatricolporites, Cupuliferoipollenites, Zonocostites, Cyrillaceaepollenites, Nyssapollenites, Intragranulitricolporites, Intrabaculitricolporites, Fususpollenites, Microsculptitricolporites.* Description d'un genre de forme nouveaux.

Mots clés: Palynologie, Tertiaire inférieur, Région Parisienne, France.

Note. – Les lames ont été déposées dans le Laboratoire de Palynologie E.P.H.E., Paris, France.

Fgen.: *Polycolpites* COUPER 1953

1. *Polycolpites transdanubicus* KEDVES 1978
   (Planche 2.1., fig. 1,2)

Présence: Sparnacien moyen: Chavot.
Appartenance botanique probable: *Rubiaceae, Carlemannia.*

Fgen.: *Cupuliferoidaepollenites* R. POTONIÉ 1960

1. *Cupuliferoidaepollenites liblarensis* (THOMSON 1950 in POTONIÉ, THOMSON et THIERGART) R. POTONIÉ 1960
   (Planche 2.1., fig. 3–18)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-3, Arpenty B_1-118; Sparnacien moyen: Boulogne-la-Grasse 21/6-18, Chavot, Sinceny 21/6-12; Sparnacien supérieur: Guitrancourt B_1-32, Neuilly-46, Neuilly-37, Sinceny 21/6-7, 8, 21/6-9, 10, 11; Sparnacien, Facies Argiles des Flandres: Templeuve-en-Pévèle B_1-25, Watten B_1-6; Cuisien supérieur: Troesnes I–III, Cuise-2, Fosses I–III, Lutétien supérieur: Paris, Austerlitz.

Appartenance botanique probable: *Fagaceae* v. *Leguminosae.*

2. *Cupuliferoidaepollenites quisqualis* (R. POTONIÉ 1934) R. POTONIÉ 1960
   (Planche 2.1., fig. 19–22)

Présence: Thanétien, zone II: Anizy-le-Château; Thanétien, zone III: Rollot 21/6-16; Sparnacien inférieur: Arpenty B_I-118; Sparnacien moyen: Sinceny 21/6-12; Sparnacien supérieur: Guitrancourt B_I-32, Neuilly-46, Sinceny 21/6-7, 8; Sparnacien, Facies Argiles des Flandres: Watten B_I-6, Cuisien supérieur: Cuise-2.

Appartenance botanique probable: *Fagaceae* v. *Leguminosae*.

3. *Cupuliferoidaepollenites* fsp.
(Planche 2.1., fig. 23–26)

Présence: Thanétien, zone II: Anizy-le-Château; Sparnacien moyen: Boulogne-la-Grasse 21/6-18; Sinceny 21/6-12; Sparnacien supérieur: Neuilly-37, Sinceny 21/6-9, 10, 11; Sparnacien, Facies Argiles des Flandres: Templeuve-en-Pévèle B_I-25, Lutétien supérieur: Paris, Austerlitz.

Appartenance botanique probable: cf. *Leguminosae*.

Fgen.: *Scabraticolpites* (VAN DER HAMMEN 1956) GONZÁLEZ GUZMÁN 1967

1. *Scabratricolpites tibialis* GONZÁLEZ GUZMÁN 1967
(Planche 2.1., fig. 27–36)

Présence: Thanétien, zone II: Anizy-le-Château; Thanétien, zone III: Rollot 21/6-16; Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a, 21/6-3, Arpenty B_I-118; Sparnacien moyen: Chavot, Sinceny 21/6-12; Sparnacien supérieur: Neuilly-46, Sinceny 21/6-9, 10, 11; Cuisien supérieur: Troesnes I–III.

2a. *Scabratricolpites microechinus* (KEDVES 1965) KEDVES 1978 subfsp. *microechinus*
(Planche 2.1., fig. 37–40)

Présence: Thanétien, zone II: Anizy-le-Château: Sparnacien moyen: Boulogne-la-Grasse 21/6-18; Sparnacien supérieur: Sinceny 21/6-7, 8; Cuisien supérieur: Troesnes I–III.

2b. *Scabratricolpites microechinus* (KEDVES 1965) KEDVES 1978 subfsp. *minor* KEDVES 1965
(Planche 2.1., fig. 41–44)

Présence: Thanétien, zone II: Anizy-le-Château; Thanétien zone III: Rollot 21/6-16; Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a, Arpenty B_I-118.

3. *Scabratricolpites hungaricus* KEDVES 1978
(Planche 2.1., fig. 45–52)

Présence: Sparnacien moyen: Boulogne-la-Grasse 21/6-18, Sinceny 21/6-12; Sparnacien supérieur: Guitrancourt B_I-32, Nointel, Neuilly-46, Sinceny 21/6-9, 10, 11; Sparnacien, Facies Argiles des Flandres: Templeuve-en-Pévèle B_I-25.

Appartenance botanique probable: *Fagaceae*, cf. *Quercus*.

Fgen.: *Quercoidites* R. POTONIÉ 1960 ex R. POTONIÉ, THOMSON et THIERGART 1950

1. *Quercoidites microhenrici* (R. POTONIÉ 1931) R. POTONIÉ 1960
(Planche 2.1., fig. 53-64)

Syn.: 1976 *Scabratricolpites microhenrici* (TH. et PF. 1953) n. comb., p. 18.

Présence: Thanétien, zone II: Anizy-le-Château; Sparnacien inférieur: Saint Léger-aux-Bois 21/6-62, Arpenty B_I-118; Sparnacien moyen: Chavot; Sparnacien supérieur: Neuilly-46, Sinceny 21/6-7, 8; Sparnacien, Facies Argiles des Flandres: Templeuve-en-Pévèle B_I-25, Watten B_I-6; Cuisien supérieur: Cuise-2.

Appartenance botanique probable: *Fagaceae* cf. *Quercus*.

Fgen.: *Tricolpites* (ERDTMAN 1947, COOKSON 1947, ROSS 1949, COUPER 1953) emend. R. POTONIÉ 1960

1. *Tricolpites* cf. *grandiosus* KEDVES 1978
   (Planche 2.1., fig. 65,66)

Présence: Sparnacien moyen: Chavot.

2. *Tricolpites crassus* (LIUBOMIROVA 1965) n. comb.
   (Planche 2.1., fig. 67,68)

Syn.: 1965 *Corylopsis crassa* LIUBOMIROVA sp. nov., p. 204–206, pl. IV, 1–3, holotype, 1.

Présence: Cuisien supérieur: Cuise-2.

Appartenance botanique probable: *Fagaceae, Corylopsis.*

3. *Tricolpites compactus* (LIUBOMIROVA 1965) n. comb.
   (Planche 2.1., fig. 69–76)

Syn.: 1965 *Corylopsis compacta* LIUBOMIROVA sp. nov., p. 206–207, pl. IV, 4-8, holotype, 4.

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a; Sparnacien supérieur: Neuilly-46, Neuilly-37; Sparnacien, Facies Argiles des Flandres: Watten B_1-6; Cuisien supérieur: Troesnes I–III, Cuise-2.

Appartenance botanique probable: *Fagaceae, Corylopsis.*

Fgen.: *Retitricolpites* (VAN DER HAMMEN 1956) VAN DER HAMMEN et WIJMSTRA 1964

1. *Retitricolpites maledictus* GONZÁLEZ GUZMÁN 1967
   (Planche 2.1., fig. 77–86)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a; Sparnacien moyen: Sinceny 21/6-12; Sparnacien supérieur: Sinceny 21/6-7, 8, 21/6-9, 10, 11; Sparnacien, Facies Argiles des Flandres: Templeuve-en-Pévèle B_1-25; Lutétien supérieur: Paris, Austerlitz.

Fgen.: *Striatopollis* KRUTZSCH 1959

1. *Striatopollis microstriatus* (GRUAS-CAVAGNETTO 1968) n. comb.
   (Planche 2.2., fig. 1,2)

Syn.: 1968 *Tricolpopollenites microstriatus* n. fsp., GRUAS-CAVAGNETTO, p. 63,64, Pl. VI, 16.

Présence: Cuisien supérieur: Troesnes I–III.

Fgen.: *Pistillipollenites* ROUSE 1962

ELSIK (1968) a emendé ce genre, et ajouté ici les pollens colpoidorés aussi. ROUSE et SRIVASTAVA (1970) n'ont pas accepté cette emendation, et avec les documents de MeB ont élargi la connaissance de ces pollens, en donnant une description nouvelle. L'affinité botanique, avec la significance paléoecologie a été discuté.

1. *Pistillipollenites mcgregori* ROUSE 1962
   (Planche 2.2., fig. 3–8)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a, 21/6-3; Sparnacien moyen: Boulogne-la-Grasse 21/6-18, Chavot, Sinceny 21/6-12; Sparnacien supérieur: Guitrancourt B_1-32. Sinceny 21/6-7, 8; Cuisien supérieur: Fosses I–III.

Fgen.: *Aesculiidites* ELSIK 1968

1. *Aesculiidites circumstriatus* (FAIRCHILD 1966) ELSIK 1968 (Planche 2.2., fig. 9–12)

Présence: Sparnacien moyen: Boulogne-la-Grasse 21/6-18, Sinceny 21/6-12; Sparnacien supérieur: Sinceny 21/6-9, 10, 11; Sparnacien, Facies Argiles des Flandres: Watten B_1-6.

Appartenance botanique probable: *Hippocastanaceae*.

Fgen.: *Psilatricolporites* (VAN DER HAMMEN 1956) VAN DER HAMMEN et WIJMSTRA 1964

1. *Psilatricolporites parmularius* (R. POTONIÉ 1934) KEDVES 1978 (Planche 2.2., fig. 13–22)

Syn.: 1973 *Quercus tenella* sp. n. KULKOVA, p. 43, pl. II, 13,14.
1974 *Eucommia parmularia* (R. POT.) ANANOVA comb. nov., p. 174,175, pl. XXVIII, 5,6.

Présence: Thanétien, zone II: Anizy-le-Château; Sparnacien inférieur: Arpenty B_1-118; Sparnacien moyen: Boulogne-la-Grasse 21/6-18, Chavot; Sparnacien supérieur: Guitrancourt B_1-32, Neuilly-46, Neuilly-37, Sinceny 21/6-7, 8; Lutétien supérieur: Paris, Austerlitz.

Appartenance botanique probable: *?Eucommiaceae*.

2. *Psilatricolporites globus* (H. DEÁK 1960) KEDVES 1978 (Planche 2.2., fig. 23,24)

Présence: Sparnacien supérieur: Guitrancourt B_1-32, Neuilly-46.

3. *Psilatricolporites mansfeldensis* (KRUTZSCH 1969) n. comb. (Planche 2.2., fig. 25,26)

Syn.: 1969 *Tricolporopollenites mansfeldensis* n. fsp., KRUTZSCH, p. 473, pl. 1, 25–28.

Présence: Sparnacien supérieur: Neuilly-37.

Appartenance botanique probable: *?Rhizophoraceae*.

4. *Psilatricolporites psilatus* ROCHE et SCHULER 1976 (Planche 2.2., fig. 27–30)

Présence: Thanétien, zone II; Anizy-le-Château; Sparnacien supérieur: Neuilly-46.

Appartenance botanique probable: *Diospyros*.

5. *Psilatricolporites gregussii* KEDVES 1978 (Planche 2.2., fig. 31,32)

Présence: Thanétien, zone II: Anizy-le-Château; Sparnacien supérieur: Neuilly-37.

Appartenance botanique probable: *?Fabaceae*.

6. *Psilatricolporites laevigatoides* KEDVES 1978 (Planche 2.2., fig. 33,34)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a; Sparnacien supérieur: Neuilly-37; Sparnacien, Facies Argiles des Flandres: Templeuve-en-Pévèle B_1-25, Watten B_1-6.

Appartenance botanique probable: *Fabaceae*.

Fgen.: *Cupuliferoipollenites* R. POTONIÉ 1960 non 1951

1. *Cupuliferoipollenites pusillus* (R. POTONIÉ 1934) R. POTONIÉ 1960
(Planche 2.2., fig. 35–44)

Présence: Thanétien, zone II: Anizy-le-Château; Thanétien, zone III: Rollot 21/6-16; Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a, 21/6-3, Arpenty B_1-118; Sparnacien moyen: Chavot, Sinceny 21/6-12; Sparnacien supérieur: Guitrancourt B_1-32, Neuilly-46, Neuilly-37; Sparnacien, Facies Argiles des Flandres: Templeuve-en-Pévèle, B_1-25, Watten B_1-6; Lutétien supérieur: Paris, Austerlitz.

Appartenance botanique probable: *Fagaceae*, cf. *Castanea*.

2. *Cupuliferoipollenites oviformis* (R. POTONIÉ 1931) R. POTONIÉ 1960
(Planche 2.2., fig. 45–54)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a, 21/6-3, Arpenty B_1-118; Sparnacien moyen: Boulogne-la-Grasse 21/6-18, Chavot, Sinceny 21/6-12; Sparnacien supérieur: Guitrancourt B_1-32, Noitel, Neuilly-46, Neuilly-37, Sinceny 21/6-9, 10, 11; Sparnacien Facies Argiles des Flandres: Templeuve-en-Pévèle B_1-25, Watten B_1-6; Cuisien supérieur: Troesnes I–III; Lutétien supérieur: Paris, Austerlitz.

Appartenance botanique probable: *Fagaceae*, cf. *Castanea*.

3. *Cupuliferoipollenites insleyanus* (TRAVERSE 1955) R. POTONIÉ 1960
(Plate 2.2., fig. 55–62)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a, 21/6-3; Sparnacien moyen: Chavot; Sparnacien, Facies Argiles des Flandres: Templeuve-en-Pévèle.

Appartenance botanique probable: *Fagaceae, Castanea*.

4. *Cupuliferoipollenites kovácsae* (KEDVES 1965) KEDVES 1978
(Planche 2.2., fig. 63–66)

Présence: Thanétien, zone II: Anizy-le-Château; Sparnacien moyen: Chavot, Sinceny 21/6-12; Sparnacien, Facies Argiles des Flandres: Watten B_1-6; Lutétien supérieur: Paris, Austerlitz.

Appartenance botanique probable: *Fagaceae, Pasania*.

5. *Cupuliferoipollenites microporocingulum* (KRUTZSCH et VANHOORNE 1977) n. comb.
(Planche 2.2., fig. 67,68)

Syn.: 1977 *Tricolporopollenites microporocingulum* n. fsp., KRUTZSCH et VANHOORNE, p. 71, pl. 29, 60, 61.

Présence: Sparnacien moyen: Chavot.

Fgen.: *Zonocostites* GERMERAAD, HOPPING et MULLER 1968

1. *Zonocostites* cf. *ramonae* GERMERAAD, HOPPING et MULLER 1968
(Planche 2.2., fig. 69–76)

Présence: Sparnacien supérieur: Neuilly-46, Neuilly-37.

Appartenance botanique probable: *Rhizophoraceae, Rhizophora–Bruguiera* type.

Fgen.: *Cyrillaceaepollenites* (MÜRRIGER et PFLUG 1951) R. POTONIÉ 1960

1. *Cyrillaceaepollenites barghoorniacus* (TRAVERSE 1955) R. POTONIÉ 1960
(Planche 2.2., fig. 77–82)

Présence: Sparnacien supérieur: Neuilly-46, Sinceny 21/6-7, 8.

Appartenance botanique probable: *Cyrillaceae, Clethraceae* v. *Theaceae*.

Fgen.: *Nyssapollenites* THIERGART 1938

1. *Nyssapollenites kruschi* (R. POTONIÉ 1934) SIMONCSICS 1969 subfsp. *analepticus* (R. POTONIÉ 1934) SIMONCSICS 1969
(Planche 2.2., fig. 83–88)

Syn.: 1974 *Nyssa analeptica* (R. POT. et VEN.) ANANOVA comb. nov., p. 169.
1976 *Psilatricolporites kruschi* (TH. et PF. 1953) n. comb. ROCHE et SCHULER, p. 21.

Présence: Thanétien, zone II: Anizy-le-Château; Sparnacien inférieur: Arpenty B_1-118, Sparnacien moyen: Chavot; Sparnacien supérieur: Guitrancourt B_1-32, Neuilly-46, Neuilly-37.

Appartenance botanique probable: *Nyssaceae.*

Fgen.: *Intragranulitricolporites* KEDVES 1978

1. *Intragranulitricolporites wolffi* KEDVES 1978
(Planche 2.2., fig. 89–92)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-3; Sparnacien supérieur: Neuilly-46.

Appartenance botanique probable: *Rhamnaceae.*

2. *Intragranulitricolporites microdesmiaeformis* (KEDVES 1965) KEDVES 1978
(Planche 2.3., fig. 1–8)

Présence: Thanétien, zone II: Anizy-le-Château; Thanétien, zone III: Rollot 21/6-16; Sparnacien supérieur: Guitrancourt B_1-32, Sinceny 21/6-7, 8; Sparnacien, Facies Argiles des Flandres: Watten B_1-6; Lutétien supérieur: Paris, Austerlitz.

Appartenance botanique probable: *Euphorbiaceae.*

Fgen.: *Intrabaculitricolporites* KEDVES 1978

1. *Intrabaculitricolporites abouziarovae* KEDVES 1978
(Planche 2.3., fig. 9,10)

Présence: Sparnacien supérieur: Neuilly-37.

Appartenance botanique probable: *Anacardiaceae.*

2. *Intrabaculitricolporites bonai* KEDVES 1978
(Planche 2.3., fig. 11–18)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a, 21/6-3; Sparnacien supérieur: Neuilly-46, Neuilly-37.

Appartenance botanique probable: *?Erythroxylaceae.*

3. *Intrabaculitricolporites intrabaculatus* KEDVES 1978
(Planche 2.3., fig. 19–26)

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-3; Sparnacien supérieur: Nointel.

4. *Intrabaculitricolporites loksbergensis* (KRUTZSCH et VANHOORNE 1977) n. comb.
(Planche 2.3., fig. 27–34)

Syn.: 1977 *Tricolporopollenites loksbergensis* n. fsp. KRUTZSCH et VANHOORNE, p. 86, pl. 37, 1–7, holotype, 4.

Présence: Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a, 21/6-3; Sparnacien supérieur: Nointel.

5. *Intrabaculitricolporites feugueuri* (GRUAS-CAVAGNETTO 1966) n. comb. (Planche 2.3., fig. 35–40)
Syn.: 1966 *Tricolporopollenites feugueuri* n. sp., GRUAS-CAVANGETTO, p. 63, pl. 3, 6.
Présence: Sparnacien supérieur: Nointel; Lutétien supérieur: Paris, Austerlitz.

Fgen.: *Fususpollenites* KEDVES 1978

1. *Fususpollenites fusus* (R. POTONIÉ 1934) KEDVES 1978 (Planche 2.3., fig. 41–46)
Syn.: 1976 *Psilatricolporites cingulum* (TH. et PF. 1953) *fusus* (TH. et PF. 1953) n. comb. ROCHE et SCHULER, p. 21.
Présence: Thanétien, zone II: Anizy-le-Château: Thanétien, zone III: Rollot 21/6-16; Sparnacien inférieur: Saint Léger-aux-Bois 21/6-6a; Sparnacien moyen: Chavot; Sparnacien supérieur: Neuilly-46, Neuilly-37; Sparnacien, Facies Argiles des Flandres: Watten B_1-6; Lutétien supérieur: Paris, Austerlitz.
Appartenance botanique probable: *Fagaceae, Castanopsis.*

Fgen.: *Microsculptitricolporites* n. fgen.
Fgen. type: *Microsculptitricolporites microsculptus* (KRUTZSCH et VANHOORNE 1977) n. comb.
(Planche 2.3., fig. 47–50)

Syn.: 1977 *Tricolporopollenites microsculptus* n. fsp., KRUTZSCH et VANHOORNE, p. 70, 71, pl. 29, 49, 50.
Diagnose
Pollens tricolporés. Surface ornée, l'ornamentation est très fine, verruqueuse – rugulée. La dimension des éléments de la sculpture est toujours sous 1 µm.
Locus typicus: Epinois.
Stratum typicum: Lignites inférieur du Landénien supérieur.
Derivatio nominis: De l'ornamentation fine.
Diagnose différencielle: La sculpture fine qui distingue du *Verrutricolporites* VAN DER HAMMEN et WIJMSTRA 1964 et du *Rugutricolporites* GONZÁLEZ GUZMÁN 1967: Le genre de forme *Yeguapollis* ELSIK 1974 ressemble à notre genre de forme nouveaux, mais les pollens d'ELSIK (1974) sont tricolporés – tricolpés, tectum est punctate – alveolate – microreticulate. Le *Granotricolporites* KEDVES 1978 est exclusivement granulate.
Présence: Sparnacien moyen: Chavot.
2. *Microsculptitricolporites huangi* (GRUAS-CAVAGNETTO 1976) n. comb. (Planche 2.3., fig. 51–54)
Syn.: 1976 *Tricolporopollenites huangi* n. fsp., GRUAS-CAVAGNETTO, p. 34, pl. 4, 3,4.
Présence: Sparnacien supérieur: Guitrancourt B_1-32.
Appartenance botanique probable: *Euphorbiaceae.*
3. *Microsculptitricolporites gracilipunctatus* (ROCHE 1969) n. comb. (Planche 2.3., fig. 55–64)
Syn.: 1969 *Tricolporopollenites gracilipunctatus* n. fsp., ROCHE, p. 138, pl. 1, 26.
Présence: Thanétien, zone II: Anizy-le-Château; Sparnacien supérieur: Guitrancourt B_1-32, Neuilly-37, Sinceny 21/6-7, 8; Cuisien supérieur: Cuise-2.
4. *Microsculptitricolporites* cf. *raguhnensis* (KRUTZSCH 1969) n. comb. (Planche 2.3., fig. 65–68)

Syn.: 1969 *Tricolporopollenites raguhnensis* n. fsp., KRUTZSCH, p. 473, pl. II, 1–24, holotype, 5.

Présence: Thanétien, zone II: Anizy-le-Château,

À suivre

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Planche 2.1.

1,2. *Polycolpites transdanubicus* KEDVES 1978, *Rubiaceae, Carlemannia*, prep.: Chavot 1/2.
3,4. *Cupuliferoidaepollenites liblarensis* (THOMSON in POTONIÉ, THOMSON et THIERGART 1950) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: 21/6-12.
5,6. *Cupuliferoidaepollenites liblarensis* (THOMSON in POTONIÉ, THOMSON et THIERGART 1950) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: 21/6-7.
7,8. *Cupuliferoidaepollenites liblarensis* (THOMSON in POTONIÉ, THOMSON et THIERGART 1950) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: 21/6-12.
9,10. *Cupuliferoidaepollenites liblarensis* (THOMSON in POTONIÉ, THOMSON et THIERGART 1950) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: 21/6-7.
11,12. *Cupuliferoidaepollenites liblarensis* (THOMSON in POTONIÉ, THOMSON et THIERGART 1950) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: 21/6-12.
13,14. *Cupuliferoidaepollenites liblarensis* (THOMSON, in POTONIÉ, THOMSON et THIERGART 1950) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: Chavot 1/1.
15,16. *Cupuliferoidaepollenites liblarensis* (THOMSON, in POTONIÉ, THOMSON et THIERGART 1950) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: Chavot 1/2.
17,18. *Cupuliferoidaepollenites liblarensis* (THOMSON, in POTONIÉ, THOMSON et THIERGART 1950) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: Chavot 1/2.
19,20. *Cupuliferoidaepollenites quisqualis* (R. POTONIÉ 1934) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: N-46-L-183-2c-118-2.
21,22. *Cupuliferoidaepollenites quisqualis* (R. POTONIÉ 1934) R. POTONIÉ 1960, *Fagaceae* v. *Leguminosae*, prep.: B_1-32-1.
23,24. *Cupuliferoidaepollenites* fsp., cf. *Leguminosae*, prep.: AT-5.
25,26. *Cupuliferoidaepollenites* fsp., cf. *Leguminosae*, prep.: 21/6-12.
27,28. *Scabratricolpites tibialis* GONZÁLEZ GUZMÁN 1967, prep.: Troesnes 1/1.
29,30. *Scabratricolpites tibialis* GONZÁLEZ GUZMÁN 1967, prep.: Chavot 1/2.
31,32. *Scabratricolpites tibialis* GONZÁLEZ GUZMÁN 1967, prep.: AT-1.
33,34. *Scabratricolpites tibialis* GONZÁLEZ GUZMÁN 1967, prep.: 21/6-16-1/5.
35,36. *Scabratricolpites tibialis* GONZÁLEZ GUZMÁN 1967, prep.: Troesnes III/4.
37,38. *Scabratricolpites microechinus* (KEDVES 1965) KEDVES 1978 subfsp. *microechinus*, prep.: Chavot 1/1.
39,40. *Scabratricolpites microechinus* (KEDVES 1965) KEDVES 1978 subfsp. *microechinus*, prep.: AT-2.
41,42. *Scabratricolpites microechinus* (KEDVES 1965) KEDVES 1978 subfsp. *minor* KEDVES 1965, prep.: B_1-118-2.
43,44. *Scabratricolpites microechinus* (KEDVES 1965) KEDVES 1978 subfsp. *minor* KEDVES 1965, prep.: 21/6-6a-1.
45,46. *Scabratricolpites hungaricus* KEDVES 1978, *Fagaceae*, cf. *Quercus*, prep.: Nointel 2/a.
47,48. *Scabratricolpites hungaricus* KEDVES 1978, *Fagaceae*, cf. *Quercus*, prep.: B_1-32-1.
49,50. *Scabratricolpites hungaricus* KEDVES 1978, *Fagaceae*, cf. *Quercus*, prep.: Chavot 1/2.
51,52. *Scabratricolpites hungaricus* KEDVES 1978, *Fagaceae*, cf. *Quercus*, prep.: 21/6-12.
53,54. *Quercoidites microhenrici* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Quercus*, prep.: AT-1.
55,56. *Quercoidites microhenrici* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Quercus*, prep.: B_1-118-2.

57,58. *Quercoidites microhenrici* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Quercus*, prep.: B_1-6-5.
59,60. *Quercoidites microhenrici* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Quercus*, prep.: Corcy 2.
61,62. *Quercoidites microhenrici* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Quercus* B_1-118-1.
63,64. *Quercoidites microhenrici* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Quercus*, Chavot 1/2.
65,66. *Tricolpites* cf. *grandiosus* KEDVES 1978, prep.: Chavot 1/2.
67,68. *Tricolpites crassus* (LIUBOMIROVA 1965) n. comb., *Fagaceae*, *Corylopsis*, prep. Cuise 2/5.
69,70. *Tricolpites compactus* (LIUBOMIROVA 1965) n. comb., *Fagaceae*, *Corylopsis*, prep.: N-46-L-183-20-118-2.
71,72. *Tricolpites compactus* (LIUBOMIROVA 1965) n. comb., *Fagaceae*, *Corylopsis*, prep.: B_1-6-5.
73,74. *Tricolpites compactus* (LIUBOMIROVA 1965) n. comb., *Fagaceae*, *Corylopsis*, prep.: Cuise 2/1.
75,76. *Tricolpites compactus* (LIUBOMIROVA 1965) n. comb., *Fagaceae*, *Corylopsis*, prep.: N-46-L-183-2c-118-2.
77,78. *Retitricolpites maledictus* GONZÁLEZ GUZMÁN 1967, prep.: Austerlitz 1/1.
79,80. *Retitricolpites maledictus* GONZÁLEZ GUZMÁN 1967, prep.: 21/6-12.
81,82. *Retitricolpites maledictus* GONZÁLEZ GUZMÁN 1967, prep.: 21/6-12.
83,84. *Retitricolpites maledictus* GONZÁLEZ GUZMÁN 1967, prep.: 21/6-7.
85,86. *Retitricolpites maledictus* GONZÁLEZ GUZMÁN 1967, prep.: 21/6-7.

Planche 2.2.

1,2. *Striatopollis microstriatus* (GRUAS-CAVAGNETTO 1968) n. comb., prep.: Troesnes III/8.
3,4. *Pistillipollenites mcgregori* ROUSE 1962, prep.: 21/6-12.
5,6. *Pistillipollenites mcgregori* ROUSE 1962, prep.: 21/6-12.
7,8. *Pistillipollenites mcgregori* ROUSE 1962, prep.: Chavot 1/1.
9,10. *Aesculiidites circumstriatus* (FAIRCHILD 1966) ELSIK 1968, *Hippocastanaceae*, prep.: 21/6-12.
11,12. *Aesculiidites circumstriatus* (FAIRCHILD 1966) ELSIK 1968, *Hippocastanaceae*, prep.: 21/6-12.
13,14. *Psilatricolporites parmularius* (R. POTONIÉ 1934) KEDVES 1978, ?*Eucommiaceae*, prep.: 21/6-18.
15,16. *Psilatricolporites parmularius* (R. POTONIÉ 1934) KEDVES 1978, ?*Eucommiaceae*, prep.: 21/6-18.
17,18. *Psilatricolporites parmularius* (R. POTONIÉ 1934) KEDVES 1978, ?*Eucommiaceae*, prep.: 21/6-7.
19,20. *Psilatricolporites parmularius* (R. POTONIÉ 1934) KEDVES 1978, ?*Eucommiaceae*, prep.: Austerlitz 1/1.
21,22. *Psilatricolporites parmularius* (R. POTONIÉ 1934) KEDVES 1978, ?*Eucommiaceae*, prep.: N-46-L-183-2c-118-2.
23,24. *Psilatricolporites globus* (H. DEÁK 1960) KEDVES 1978, prep.: N-46-L-183-2c-118-2.
25,26. *Psilatricolporites mansfeldensis* (KRUTZSCH 1969) n. comb., *Rhizophoraceae*, prep.: N-37-L-183-2c-118-1.
27,28. *Psilatricolporites psilatus* ROCHE et SCHULER 1976, *Diospyros*, prep.: N-46-L-183-2c-118-2.
29,30. *Psilatricolporites psilatus* ROCHE et SCHULER 1976, *Diospyros*, prep.: AT-1.
31,32. *Psilatricolporites gregussii* KEDVES 1978, ?*Fabaceae*, prep.: AT-6.
33,34. *Psilatricolporites laevigatoides* KEDVES 1978, *Fabaceae*, prep.: N-37-L-118-2c-118-1.
35,36. *Cupuliferoipollenites pusillus* (R. POTONIÉ 1934) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: B_1-25-5.
37,38. *Cupuliferoipollenites pusillus* (R. POTONIÉ 1934) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: 21/6-12.
39,40. *Cupuliferoipollenites pusillus* (R. POTONIÉ 1934) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: B_1-32-1.
41,42. *Cupuliferoipollenites pusillus* (R. POTONIÉ 1934) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: 21/6-12.
43,44. *Cupuliferoipollenites pusillus* (R. POTONIÉ 1934) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: AT-1.
45,46. *Cupuliferoipollenites oviformis* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: 21/6-12.
47,48. *Cupuliferoipollenites oviformis* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: 21/6-6a.
49,50. *Cupuliferoipollenites oviformis* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: 21/6-12.

51,52. *Cupuliferoipollenites oviformis* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: B_1-25-7.
53,54. *Cupuliferoipollenites oviformis* (R. POTONIÉ 1931) R. POTONIÉ 1960, *Fagaceae*, cf. *Castanea*, prep.: Chavot 1/2.
55,56. *Cupuliferoipollenites insleyanus* (TRAVERSE 1955) R. POTONIÉ 1960, *Fagaceae, Castanea*, prep.: Chavot 1/1.
57,58. *Cupuliferoipollenites insleyanus* (TRAVERSE 1955) R. POTONIÉ 1960, *Fagaceae, Castanea*, prep.: 21/6-6a-5.
59,60. *Cupuliferoipollenites insleyanus* (TRAVERSE 1955) R. POTONIÉ 1960, *Fagaceae, Castanea*, prep.: 21/6-3a.
61,62. *Cupuliferoipollenites insleyanus* (TRAVERSE 1955) R. POTONIÉ 1960, *Fagaceae, Castanea*, prep.: Chavot 1/1.
63,64. *Cupuliferoipollenites kovácsae* (KEDVES 1965) KEDVES 1978, *Fagaceae, Pasania*, prep.: B_1-32-1.
65,66. *Cupuliferoipollenites kovácsae* (KEDVES 1965) KEDVES 1978, *Fagaceae, Pasania*, prep.: Chavot 1/1.
67,68. *Cupuliferoipollenites microporocingulum* (KRUTZSCH et VANHOORNE 1977) n. comb., prep.: Chavot 1/2.
69,70. *Zonocostites ramonae* GERMERAAD, HOPPING et MULLER 1968, *Rhizophoraceae, Rhizophora-Bruguieria* type, prep.: N-46-L-183-2c-118-2.
71,72. *Zonocostites ramonae* GERMERAAD, HOPPING et MULLER 1968, *Rhizophoraceae, Rhizophora-Bruguieria* type, prep.: N-46-L-183-2c-118-2.
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Planche 2.3.

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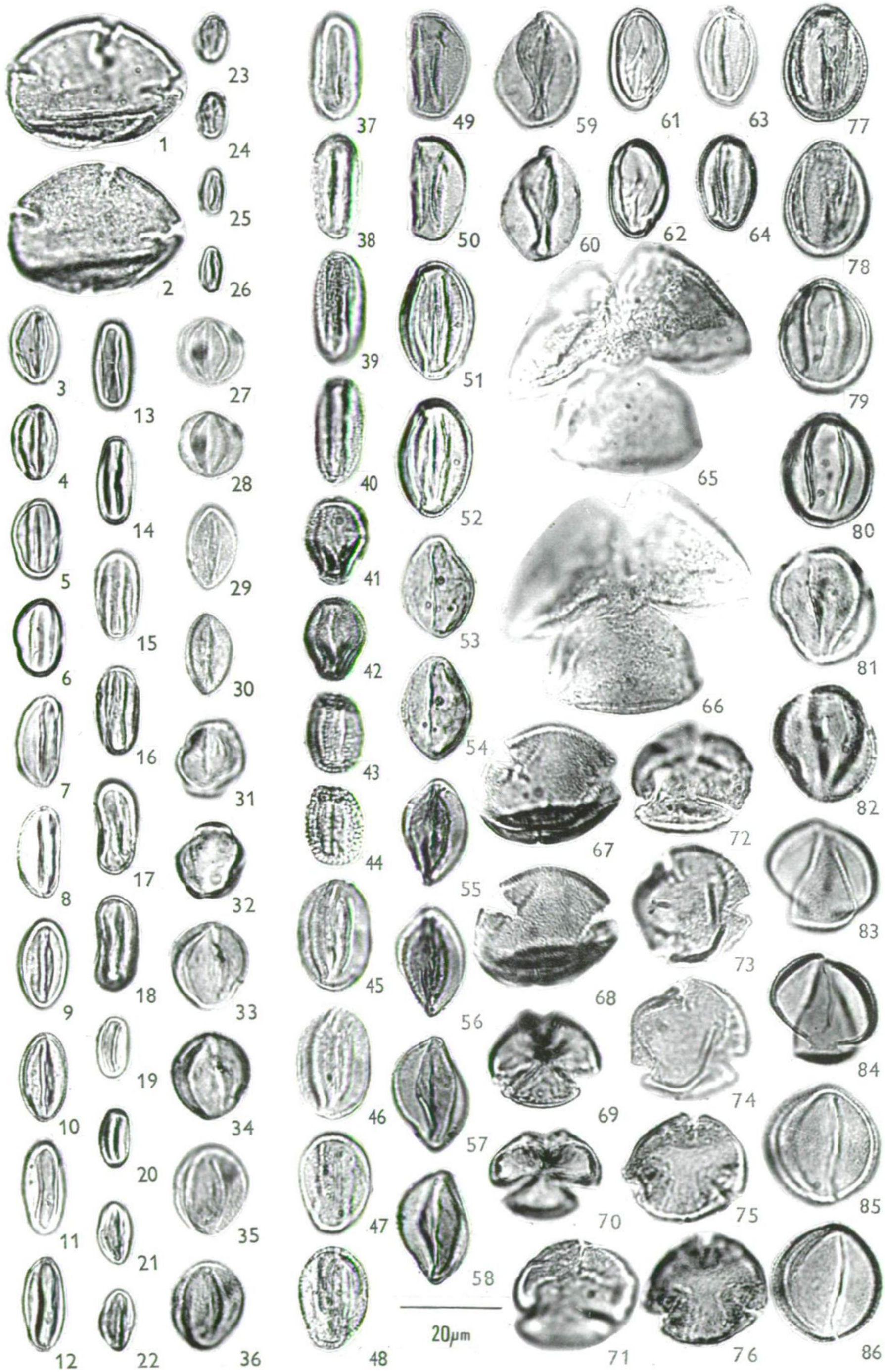

Planche 2.1.

Planche 2.2

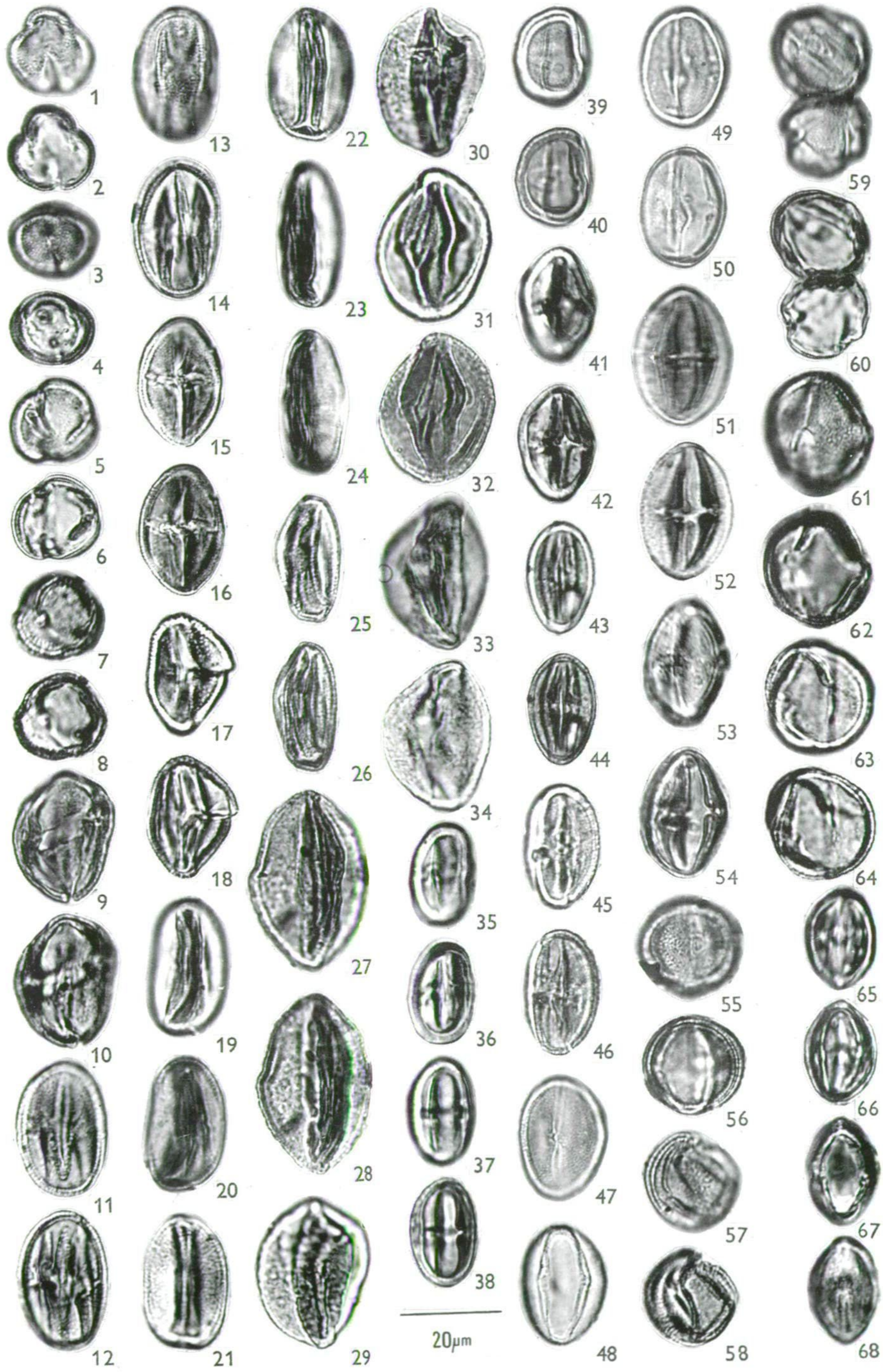

Planche 2.3.

3. EXPERIMENTAL STUDIES ON BOTRYOCOCCUS COLONIES FROM HUNGARIAN UPPER TERTIARY OIL SHALE

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Abstract

In this contribution the results of the following new investigations are presented: 1. Symmetry operations on the partially degraded and fragmented colony of fossil *Botryococcus braunii*. Quasi-crystalloid biopolymer skeleton and quasi-equivalent highly organized units are observed to be present within the same fragment. Four pentagon biopolymer units were selected from the bordering zone of the two kinds of symmetries and their structure was studied by rotation method. These observations have revealed different relationships between quasi-crystalloid and quasi-equivalent biopolymer system. 2. Colonies were partially dissolved with diluted diethylamine and merkaptoethanol for 30, 60, 90, 120 and 150 days. Then the fragmented organic remnants were investigated with TEM method. This experiment dissolved in the first place the molecular system sensu strictu. Different results were observed when the colonies were partially degraded with concentrated and dilute organic solvents (diethylamine, merkaptoethanol).

Key words: Botryococcus, fossil, Upper Tertiary, Hungary, TEM, biopolymer structure.

Introduction

The alga *Botryococcus braunii* KÜTZ., generally occurring in fresh waters has been determined to possess a high hydrocarbon production potential. It has attracted the attention of various investigators with regard to the different aspects of studies (GUY-OHLSON, 1992, VÉR, 1994, BATTEN and GRENFELL 1996). TEM structure of fossil *Botryococcus* colonies isolated from Hungarian oil shale were published by KEDVES (1983). The oil reservoir function of the holes, present in the mucilage was also emphasized in this paper. Later, biopolymer structure and symmetry operations results were published (KEDVES 1986a,b, 1987, 1988, KEDVES, ROJIK and VÉR, 1991). The peculiarity of the regular basic pentagons was discussed (KEDVES, TÓTH and FARKAS, 1993). The radial rotation method was used for the first time on the fossil *Botryococcus* colonies (KEDVES, TÓTH and VÉR, 1993, 1995). The highly organized biopolymer units may be modelled with fullerenes. Quasi-periodic and quasi-equivalent biopolymer structures are present in the wall of the colonies of *Botryococcus braunii* KÜTZ. These two kinds of structures are completely different.

The aim of our new investigations are as follows:

1. To decipher the relationships between quasi-periodic and quasi-equivalent biopolymer structures.

2. To determine the effect of the long-duration partial dissolution with diluted diethylamine and merkaptoethanol on the material under study. These chemicals were used succesfully to degrade the recent pollen grains.

Materials and Methods

The *Botryococcus* colonies were isolated from the oil shale with HNO_3 aq. dil. The isolated colonies were washed carefully in distilled water, and were investigated with the LM and the TEM method. To discover the biopolymer structure of the fossil *Botryococcus* colonies we have used several chemicals. In this paper we are dealing with methods which were used for the present studies only.

1. Partial degradation and fragmentation of the *Botryococcus* colonies

Experiment No: 924. – 1 ml merkaptoethanol cc. was added to 10 mg of dried *Botryococcus* colonies. Material was then kept for 24^{hrs} at 30 °C temperature. After washing, the residues were fragmented with a magnetic stirrer for 30 minutes. The fragments were investigated on a TESLA BS-500 TEM (resolution 6 Å) at the J. A. University, Faculty of Science, Electron Microscope Laboratory.

The modified Markham rotation method was first published in 1989 (KEDVES) and several further methodological papers were published later.

2. Partial degradation with diluted organic solvents

5 ml distilled water and 0.2 ml organic solvent were added to 5 mg dried *Botryococcus* colonies. The dissolution was made in a thermostat at 30 °C.

No of experiment	Solvents		Length of time in days
	diethylamine	merkaptoethanol	
1895	+		30
1896		+	30
1897	+		60
1898		+	60
1899	+		90
1900		+	90
1901	+		120
1902		+	120
1903	+		150
1904		+	150

The washed and fragmented material was investigated with an OPTON EM-902 (resolution 2-3 Å), and on a TESLA BS-540 (resolution 5 Å).

Results

The ultrastructure of the fossil *Botryococcus braunii* KÜTZ. colonies from the Hungarian oil shale (Pula) was described in the paper of the senior author in 1983. On Plate 3.1. we publish again the TEM structure of the outer part of the non-experimental colony. The figure illustrates the mucilage with spongy ultrastructure, and four cupules. The wall of the cupula is more or less compact and possesses small holes.

Partially degraded and fragmented colonies are composed of large globular units. This peculiar biopolymer structure was first published by KEDVES, ROJIK and VÉR in 1991. Plate 3.2., figs. 1,2, represents the TEM picture of more or less complete bucky-ball-like units composed of further smaller elements, and the desintegration of the larger units (Plate 3.2., fig. 2). We observed on ultrathin sections cupula composed of large globular biopolymer units.

Plate 3.3. represents the partially degraded and fragmented part of the *Botryococcus* colony. The upper part of the fragment is composed of large buckyball-like globular units. The lower part is more desintegrated quasi-crystalloid skeleton. Regular basic pentagonal biopolymer units (No 1–3) were investigated by KEDVES, TÓTH and FARKAS (1993). Biopolymers IV and V were first used for radial rotation, as an introduced new method (KEDVES, TÓTH and VÉR, 1995).

The results of the recently rotated biopolymer units, which are at the bordering of the two kinds of symmetry structures of biopolymer units may be summarized as follows.

BIOPOLYMER VI

(Plate 3.3., plate 3.4., figs. 1–6, plate 3.5., figs. 1,2)

Primary rotations

C.P.5.A.5.5. (Plate 3.4., fig. 1)

Around the basic regular pentagon altogether four circles of points of symmetry appeared. Two are composed of light and another two of dark, positive units. The first "light pentagon" is a little darker than the basic biopolymer.

C.P.5.A.5.10. (Plate 3.4., fig. 2)

There are five surrounding circles of the basic, central dark circle. The points of symmetry of the outermost dark circle are interesting and between the ten dark units there are further units surrounding a peculiar rotation area.

Secondary rotations

C.S.$X_{+2/2}$.5.5. – C.P.5.A.5.5. (Plate 3.4., fig. 3)

An irregular light pentagonal area appeared, each apex of this is connected to a more or less "U shape" units. These are surrounded by a pentagonal outer rotation area.

C.S.$X_{+4/1}$.5.5. – C.P.5.A.5.5. (Plate 3.4., fig. 5)

Interesting is the dark regular circular area around the fivefold rotation centrum. This, is followed by an irregular light area, and the outermost is a more or less pentagonal rotation area.

C.S.$X_{+4/4}$.5.5. – C.P.5.A.5.5. (Plate 3.5., fig. 1)

Dark pentagonal field is surrounded by ten dark points of symmetry surrounded by another less dark pentagon. This is followed by light and dark zones, the outermost area is not so regular, pentagonal star form.

C.S.$X_{+2/2}$.5.5. – C.P.5.A.5.10 (Plate 3.4., fig. 4)

The rotation centrum is surrounded by a dark star forming area. This is followed by five light areas which enclose dark points of symmetries. Near these areas there are secondary dark fields which are connected to the central dark star forming area.

C.S.$X_{-3/3}$.5.5. – C.P.5.A.5.10. (Plate 3.4., fig. 6)

Around the rotation centrum it is a not so dark pentagon. The apices of this pentagon are connected to further radially oriented large regular fields. No rotation area appeared, but at the outermost part a dark regular pentagonal basic unit appeared. This regular unit may be embedded into the so-called fullerene-like biopolymer structure.

C.S.$X_{-5/7}$.5.5. – C.P.5.A.5.10. (Plate 3.5., fig. 2)

After this rotation a regular pentagonal unit appeared. Each edge of this unit appears to be radially elongated which is enclosed within a pentagonal area. At the sides there are further five dark biopolymer units. This characteristic area is followed by not so well characteristic light and dark pentagonal areas. The outermost rotation area is not well delineated.

BIOPOLYMER VII
(Plate 3.3., plate 3.5., figs. 3–6, plate 3.6., figs. 1–4)

Primary rotations

C.P.5.A.5.5. (Plate 3.5., fig. 3)

The disposition of the surrounding points of symmetries is not so regular. Five light points are on the sides of the central dark pentagon. Following the basic unit radially oriented dark and light points appeared. The outermost five dark points are very characteristic. The outermost rotation area is not well delineated.

C.P.5.A.5.10. (Plate 3.5., fig. 4)

The circles of the dark and light points of symmetries are not so characteristic. But the outermost rotation area is well delimited.

Secondary rotations

C.S.$X_{+4/1}$.5.5. – C.P.5.A.5.5. (Plate 3.5., fig. 5)

Around the rotation area a dark pentagonal field appeared. Light and dark points of symmetries are around this field surrounding a pentagon. The outermost dark points of symmetries of the pentagon are similar to the outermost circle of the primary rotation.

C.S.$X_{+4/2}$.5.5. – C.P.5.A.5.5. (Plate 3.6., fig. 1)

The rotation centrum is surrounded by a light pentagonal field. This is the difference from the previous rotation. The outermost dark points of symmetry surrounding a pentagon are essentially identical to the previous secondary rotation.

C.S.$X_{+4/3}$.5.5. – C.P.5.A.5.5. (Plate 3.6., fig. 3)

In contrast to the previous one the results of this rotation are quite different. A dark star is in a light circle surrounded by a light pentagon. This is a negative rotation area the limiting zone being irregular and zigzag.

C.S.$X_{+5/1}$.5.5. – C.P.5.A.5.10. (Plate 3.5., fig. 6)

Around the rotation centrum a not so well-defined dark pentagon may be recognized. This is surrounded by light and dark points forming circles. The outermost large rotation area is more or less circular. The dark circle is surrounded by five light areas of ”L” or “T” shape.

C.S.$X_{+5/2}$.5.5. – C.P.5.A.5.10. (Plate 3.6., fig. 2)

The rotation centrum is surrounded by five light points of symmetry forming a regular pentagon. This is followed by five dark points of symmetry. The outermost area is not so characteristic but it is a perceptible pentagon.

C.S.$X_{+5/3}$.5.5. – C.P.5.A.5.10. (Plate 3.6., fig. 4)

The rotation centrum is surrounded by a dark pentagonal field. At the edges there are five light points of symmetry. Between the light points there are five half moon shaped fields. The outermost rotation area is a pentagon with dark points of symmetry at their edges.

BIOPOLYMER VIII

(Plate 3.3., plate 3.6., fig. 5, plate 3.7., figs. 1–6)

Primary rotations

C.P.5.A.5.5. (Plate 3.6., fig. 5)

This rotation picture represents well the symmetry situation of the bordering of the quasi-periodic and quasi-equivalent biopolymer structures. Around the centrum of the rotation there is a light circular field. Following this a light coloured star shaped area is observed which is constituted by five radially oriented triangles. Each apice of this star shaped area is connected to large dark biopolymer units. At the inner part of it is a light pentagon. In the middle of the sides of this light pentagon there exist further radially oriented protuberances which are essentially the apices of the light central star.

C.P.5.A.5.10. (Plate 3.6., fig. 6)

In the centrum exists a light circular field, surrounded by ten dark points of symmetry. This is followed by another lighter zone with ten radially oriented projections. A similar, but dark circle corresponds to the large dark units of the previous rotation picture. Finally a large outermost rotation zone, with ten lobes may be observed.

Secondary rotations

C.S.X.$_{+3/1}$.5.5. – C.P.5.A.5.5. (Plate 3.7., fig. 1)

This rotation did not reveal a so characteristic pentagon. Four curved large areas forming large unit and a not so characteristic fourth arms. This rotation may be characterized by the presence of irregular units.

C.S.X.$_{+3/2}$.5.5. – C.P.5.A.5.5. (Plate 3.7., fig. 3)

Altogether four pentagonal fields appeared as a result of this rotation. Two dark fields at the centre are surrounded by ten radially oriented dark fields. This is followed by a pentagon in the outermost region.

C.S.X.$_{+3/3}$.5.5. – C.P.5.A.5.5. (Plate 3.7., fig. 5)

Extremely obscure picture appeared after this kind of rotation. Around the centrum of the rotation a dark pentagon is surrounded by a lighter pentagonal field. There are large radially oriented star-shaped dark fields in the outermost region.

C.S.X$_{+3/2}$.5.5. – C.P.5.A.5.10. (Plate 3.7., fig. 2)

Around the rotation centrum a regular pentagon appeared which is connected with pentagons further, but these connections are by one of the edges and not by the sides. Probably, this is also one of the ways for the connections of the two kinds of biopolymer systems.

C.S.X$_{+3/5}$.5.5. – C.P.5.A.5.10. (Plate 3.7., fig. 4)

The rotation centrum is surrounded with one light pentagonal field. This is followed by a narrow light and dark pentagonal fields. The outermost dark field is composed of ten not so characteristic dark units.

C.S.X$_{+3/9}$.5.5. – C.P.5.A.5.10. (Plate 3.7., fig. 6)

This rotation revealed a light regular basic unit. Each sides are connected to further units which may represent a negative quasi-crystalloid system embedded in a periodic biopolymer structure.

BIOPOLYMER IX.

(Plate 3.3., plate 3.8., figs. 1–6, plate 3.9., figs. 1–3)

Remark. – The biopolymer units which were used for symmetry operations are a little away from the bordering of the quasi-crystalloid and quasi-periodic biopolymer structures.

C.P.5.A.5.5. (Plate 3.8., fig. 1)

The rotation centrum is surrounded by a light star-shaped field. Around this several light and dark points of symmetry appeared. At least six circles of alternating light and dark points may be observed. The outermost five dark points form a regular pentagon.

C.P.5.A.5.10. (Plate 3.8., fig. 2)

The large central light field is surrounded by ten dark points of symmetry. Near to this circle ten light points of symmetry appeared. This is followed by further ones. But the arrangement of the points of symmetry which are far from the centrum becomes by and by irregular.

Secondary rotations

C.S.$X_{5/1}$.5.5. – C.P.5.A.5.5. (Plate 3.8., fig. 3)

The most interesting result in this rotation is the appearance of a light pentagon surrounded by ten light points of symmetry. Several light and dark points of symmetry are around this field. The outermost rotation area is not so well-defined, but it forms a field of pentagon.

C.S.$X_{2/2}$.5.5. – C.P.5.A.5.5. (Plate 3.8., fig. 5, plate 3.9., fig. 3)

This negative network is also very important. The central pentagon is surrounded by tetragons, connected by sides, but the outermost rotation area is a pentagonal field. Within the quasi-periodic symmetry there are quasi-equivalent periodic units also.

C.S.$X_{5/3}$.5.5. – C.P.5.A.5.5. (Plate 3.9., fig. 1)

Negative regular pentagon appeared around the rotation centrum. This is followed by a dark not so regular pentagon. An irregular star-shaped light field represents the outermost rotation area.

C.S.$X_{2/1}$.5.5. – C.P.5.A.5.10. (Plate 3.8., fig. 4)

A dark regular pentagon appeared around the rotation centrum. This is followed by ten dark points of symmetry, which form another pentagon. Around this pentagon there is a light area and after this the disposition of the points of symmetry becomes irregular.

C.S.$X_{2/2}$.5.5. – C.P.5.A.5.10. (Plate 3.8., fig. 6)

A dark pentagon appeared in the centrum. The light star-like area is not so regular. The outermost rotation area is ten edged with irregular borderings.

C.S.$X_{2/3}$.5.5. – C.P.5.A.5.10. (Plate 3.9., fig. 2)

A dark area appeared after rotation composed probably of the points of symmetry. This is encircled by a light more or less pentagon composed of ten unequal points of symmetry. The outermost rotation area is irregular.

The results of the long-duration partial dissolution of the material with diluted diethylamine and merkaptoethanol may be summarized as follows: Experiments No: 1/7 – 1895 (Plate 3.10., fig. 1) and 1/7 - 1896 (Plate 3.10., fig. 2). It is clearly shown in the pictures, that from these experiments the biopolymer structures were not observed. But after 60 days of dissolution (Plate 3.10., figs. 3,4) with both solvents electron dense globular particles exhibiting different kinds of disposition were observed. Regular pentagons, linear chains and further regular and irregular patterns were observed. After 90 days of dissolution (Plate 3.10., figs. 5,6) the results are similar and/or identical to the previous one. Dissolution of material with diethylamine (Plate 3.10., fig. 7) for 120 days revealed a peculiar pattern of biopolymers. Dark globular units and peculiar alveolar system within the dimension of the biopolymers were observed. Further smaller units were also present within the molecular dimension sensu strictu. By the dissolution for 120 days with merkaptoethanol (Plate 3.10., figs. 8,9, plate 3.11., fig. 1) the ultrastructure of the pedunculus was also discovered. The originally channelled part of the wall of the pedunculus is in the state of desintegration on molecular level. Different kinds of biopolymer patterns were observed in this part also. Finally very complex molecular and biopolymer system was discovered after 150 days of dissolution (Plate 3.11., figs. 2–5).

Discussion and Conclusions

Based on symmetry operations during the present investigations we can establish the following.

1. The new results support the peculiarities of the quasi-crystalloid skeleton of the biopolymer system of the *Botryococcus braunii* colonies isolated from oil shale.
2. With regard to the relationships between the quasi-crystalloid and quasi-equivalent biopolymer structures the following results are worth mentioning:

2.1. The appearance of the larger units after fivefold rotation (Plate 3.4., fig. 4,6, plate 3.6., fig. 5, plate 3.7., figs. 1–6).

2.2. Presence of regular pentagonal biopolymer unit connected by one apex to the central pentagon (Plate 3.7., fig. 2).

2.3. Tetragonal unit being connected to the central regular pentagon by sides (Plate 3.8., fig. 5, plate 3.9., fig. 3).

It has been noticed that the use of concentrated organic solvents is better for the study of different kinds of biopolymer structures of the fossil *Botryococcus* colonies. It seems that for the fossil material in which the aromatization process is of higher degree the diluted solvents are not so effective but these can be used for the study of the recent less aromatized biopolymer structures.

Finally taking into consideration the previously obtained results on the biopolymer structures of the *Botryococcus braunii* colonies isolated from oil shale it is evident that further experiments are necessary to better understand the structure and organization of the molecular and biopolymer system of this complicated algal organism.

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Plate 3.1.

Detail of the ultrastructure of the non-experimental colony of *Botryococcus braunii* KÜTZ. isolated from Hungarian (Pula) Upper Tertiary oil shale. 15.000x. This negative (no: 3101) was used first in the paper of KEDVES 1983, Revue de Micropaléontologie 26, plate 1, fig. 7.

Plate 3.2.

Biopolymer structure of partially degraded and fragmented *Botryococcus braunii* KÜTZ. colonies.
1. More or less complete large buckyball-like globular biopolymer units. Experiment No: 925, negative no: 596, 500.000x.
2. Desintegrated large buckyball unit. The electron density of the smaller globular units are different. Linear and network-like arrangement was observed at these smaller units. Experiment No: 946, negative no: 999, 500.000x.

Plate 3.3.

TEM picture of partially degraded and fragmented *Botryococcus braunii* KÜTZ. colony. Lower part of the fragment is clearly a quasi-crystalloid biopolymer skeleton, composed of regular pentagons whereas the upper part is composed of large globular units, which may be modelled with fullerenes. The previously published biopolymer units are also enumerated (I–III, published in KEDVES, TÓTH and FARKAS, 1993, IV, V, published in KEDVES, TÓTH and VÉR, 1995). The recently investigated biopolymer units (VI–IX) are also indicated together with the globular units of the basic regular pentagon. Experiment No: 924, negative no: 586, 250.000.

Plate 3.4.

Biopolymer VI
1. Five-fold primary rotation picture. 500.000x.
2. Ten-fold primary rotation picture. 500.000x.

3–6. Secondary rotation pictures. 500.000x.

Plate 3.5.

Biopolymer VI

1,2. Secondary rotation pictures. 500.000x.

Biopolymer VII

3. Five-fold primary rotation picture. 500.000x.
4. Ten-fold primary rotation picture. 500.000x.

5,6. Secondary rotation pictures. 500.000x.

Plate 3.6.

Biopolymer VII

1–4. Secondary rotation pictures. 500.000x.

Biopolymer VIII

5. Five-fold primary rotation picture. 500.000x.
6. Ten-fold primary rotation picture. 500.000x.

Plate 3.7.

Biopolymer VIII

1–6. Secondary rotation pictures. 500.000x.

Plate 3.8.

Biopolymer IX
1. Five-fold primary rotation picture. 500.000x.
2. Ten-fold primary rotation picture. 500.000x.

3–6. Secondary rotation pictures. 500.000x.

Plate 3.9.

Biopolymer IX
1,2. Secondary rotation pictures. 500.000x.
3. Secondary rotation picture. 1,500.000x.

Plate 3.10.

Ultrastructure of partially dissolved *Botryococcus braunii* KÜTZ. colonies.
1. Experiment No: 1895, negative no: 3443, 250.000x.
2. Experiment No: 1896, negative no: 3454, 100.000x.
3. Experiment No: 1897, negative no: 3702, 25.000x.
4. Experiment No: 1898, negative no: 3707, 25.000x.
5. Experiment No: 1899, negative no: 4220, 250.000x.
6. Experiment No: 1900, negative no: 4224, 100.000x.
7. Experiment No: 1901, negative no: 4232, 1,000.000x.
8. Experiment No: 1902, negative no: 4234, 100.000x.
9. Experiment No: 1902, negative no: 4235, 250.000x.

Plate 3.11.

Ultrastructure of partially dissolved *Botryococcus braunii* KÜTZ. colonies.
1. Experiment No: 1902, negative no: 4236, 500.000x.
2. Experiment No: 1903, negative no: 4296, 250.000x.
3. Experiment No: 1903, negative no: 4297, 500.000x.
4. Experiment No: 1904, negative no: 4300, 100.000x.
5. Experiment No: 1904, negative no: 4301, 250.000x.

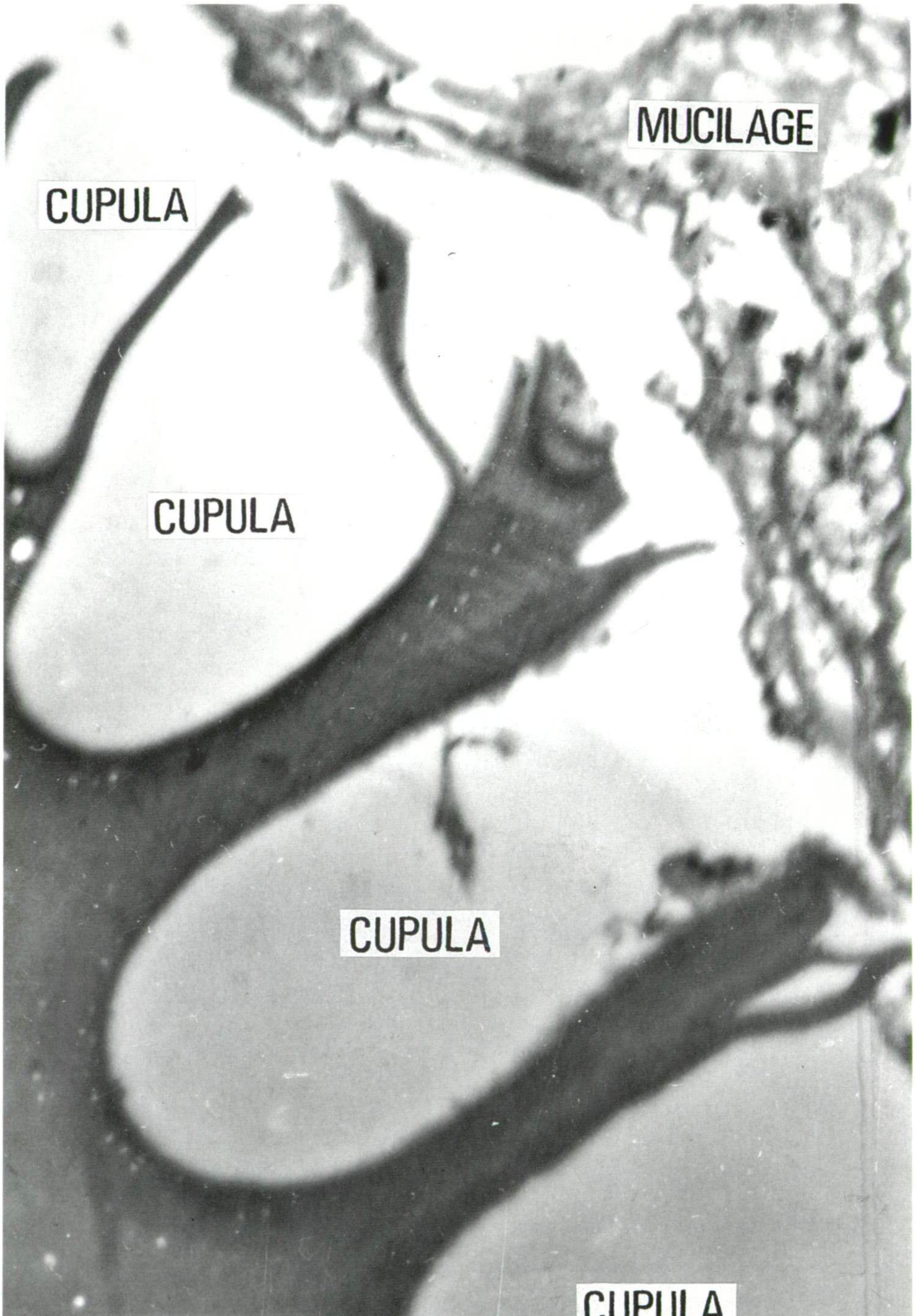


Plate 3.1.

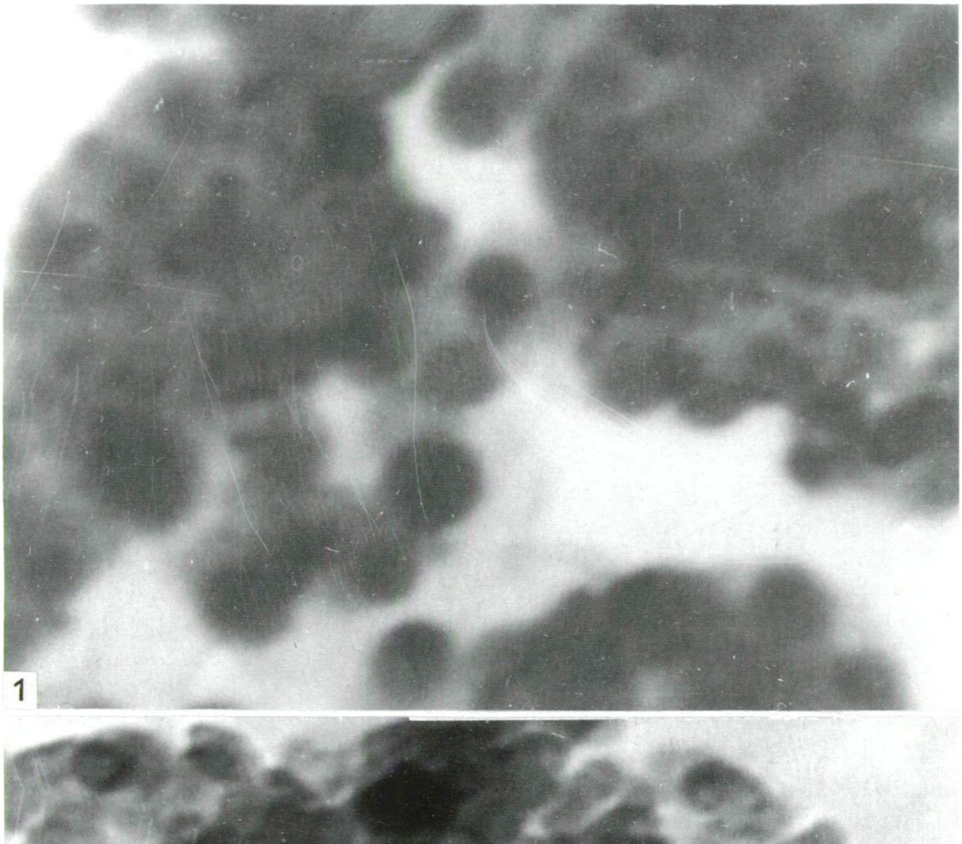


Plate 3.2.

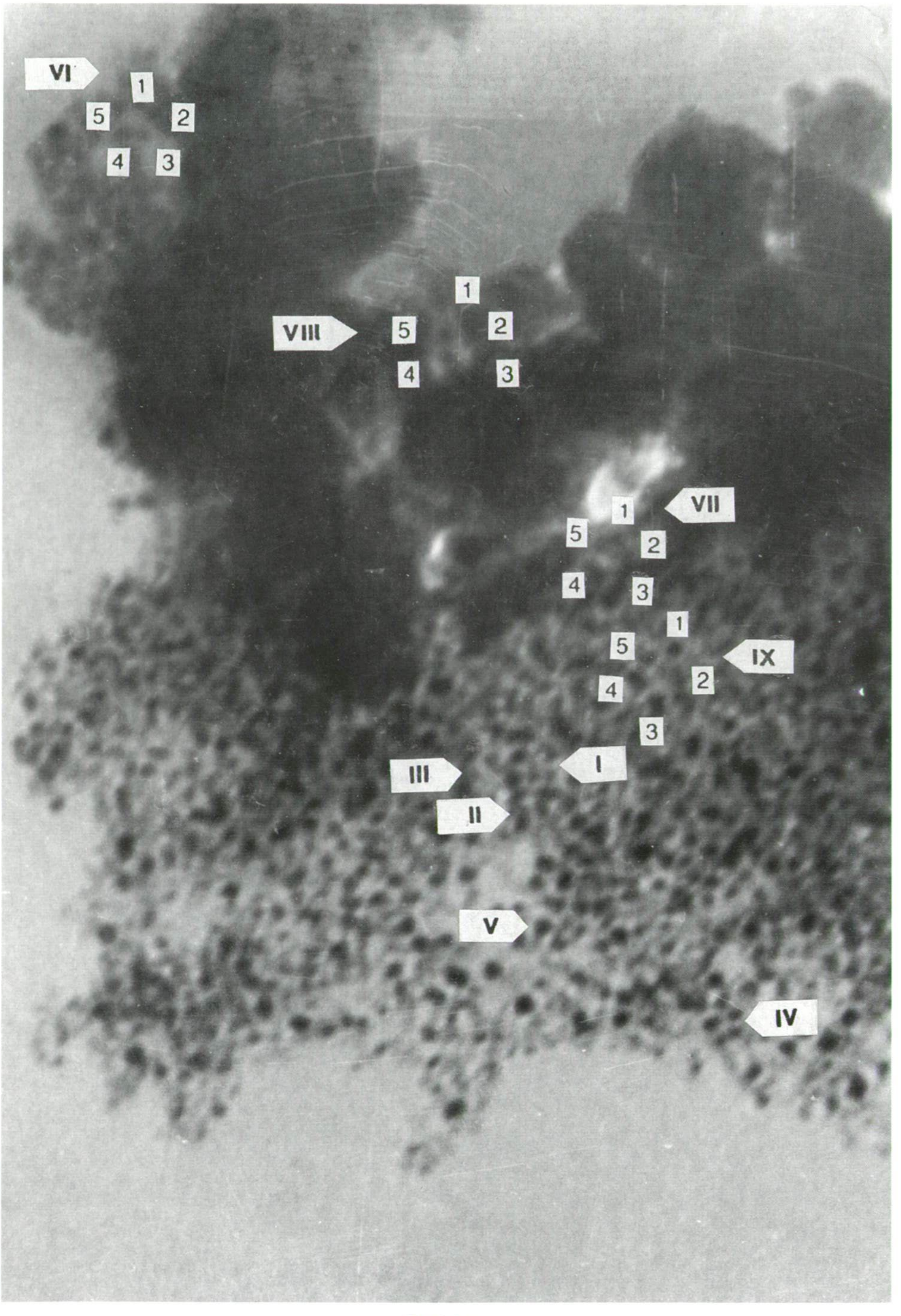
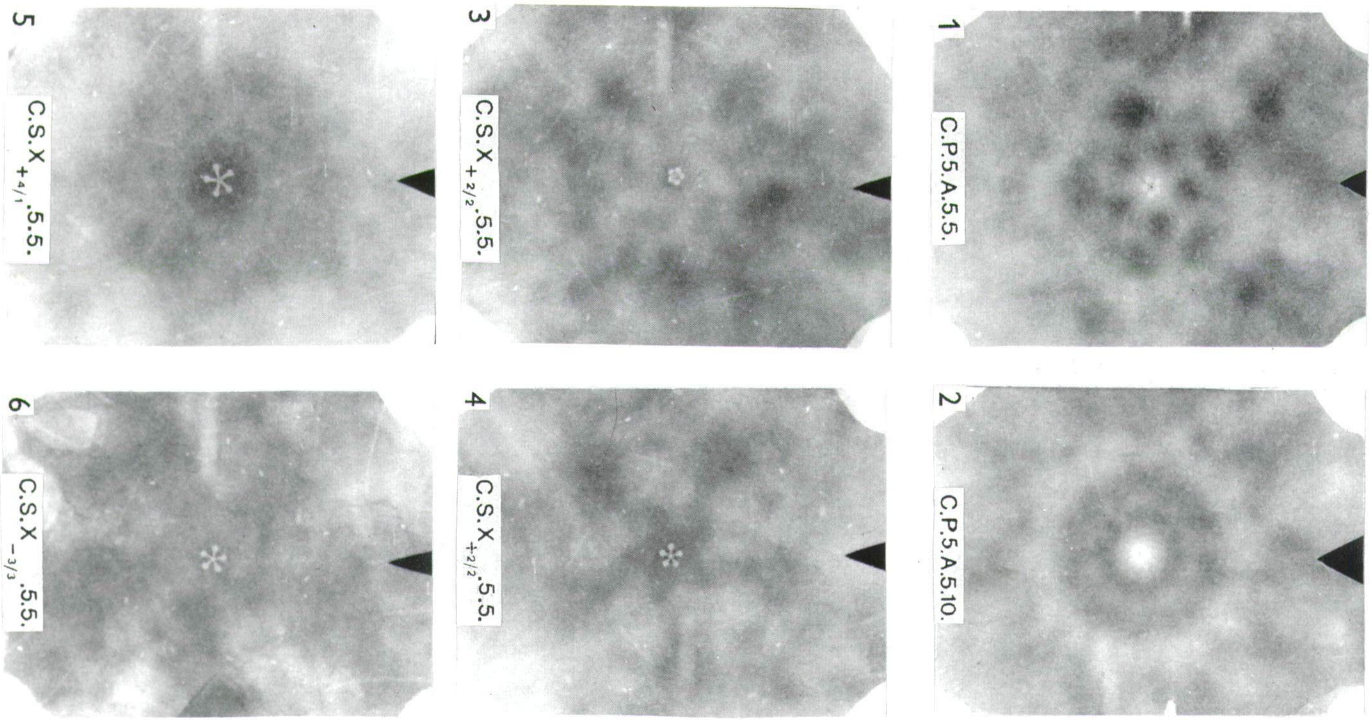


Plate 3.3.

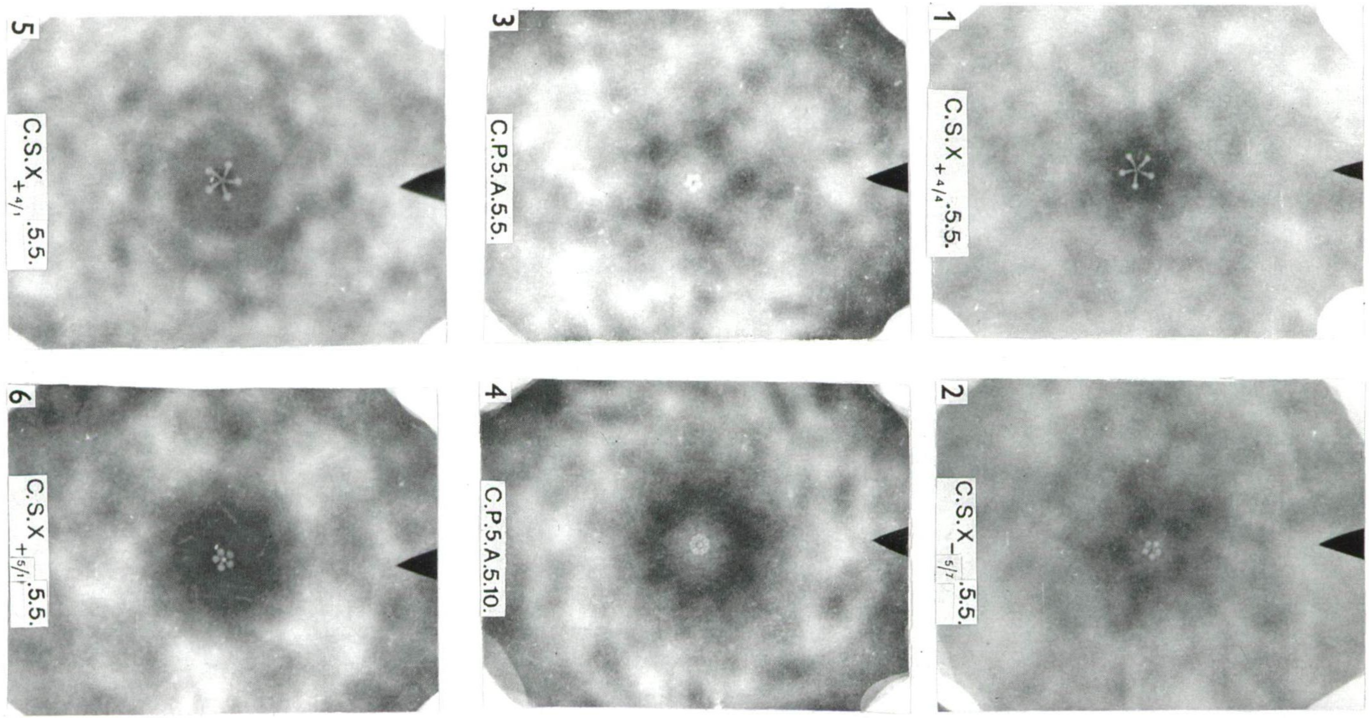
B I O P O L Y M E R VI



SECONDARY ROTATIONS PRIMARY ROTATIONS

Plate 3.4.

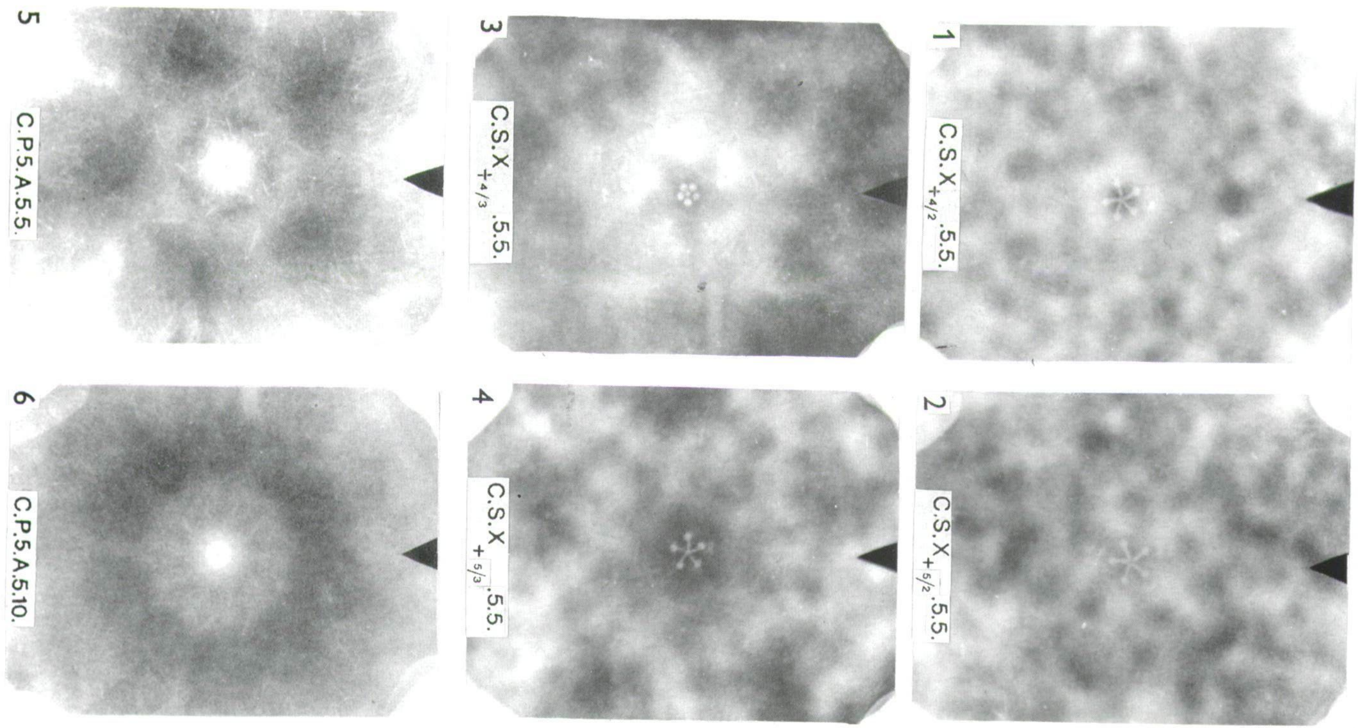
BIOPOLYMER VII BIOPOLYMER VI



SECONDARY ROTATIONS PRIMARY ROTATIONS SECONDARY ROTATIONS

Plate 3.5.

BIOPOLYMER VIII BIOPOLYMER VII



PRIMARY ROTATIONS SECONDARY ROTATIONS

Plate 3.6.

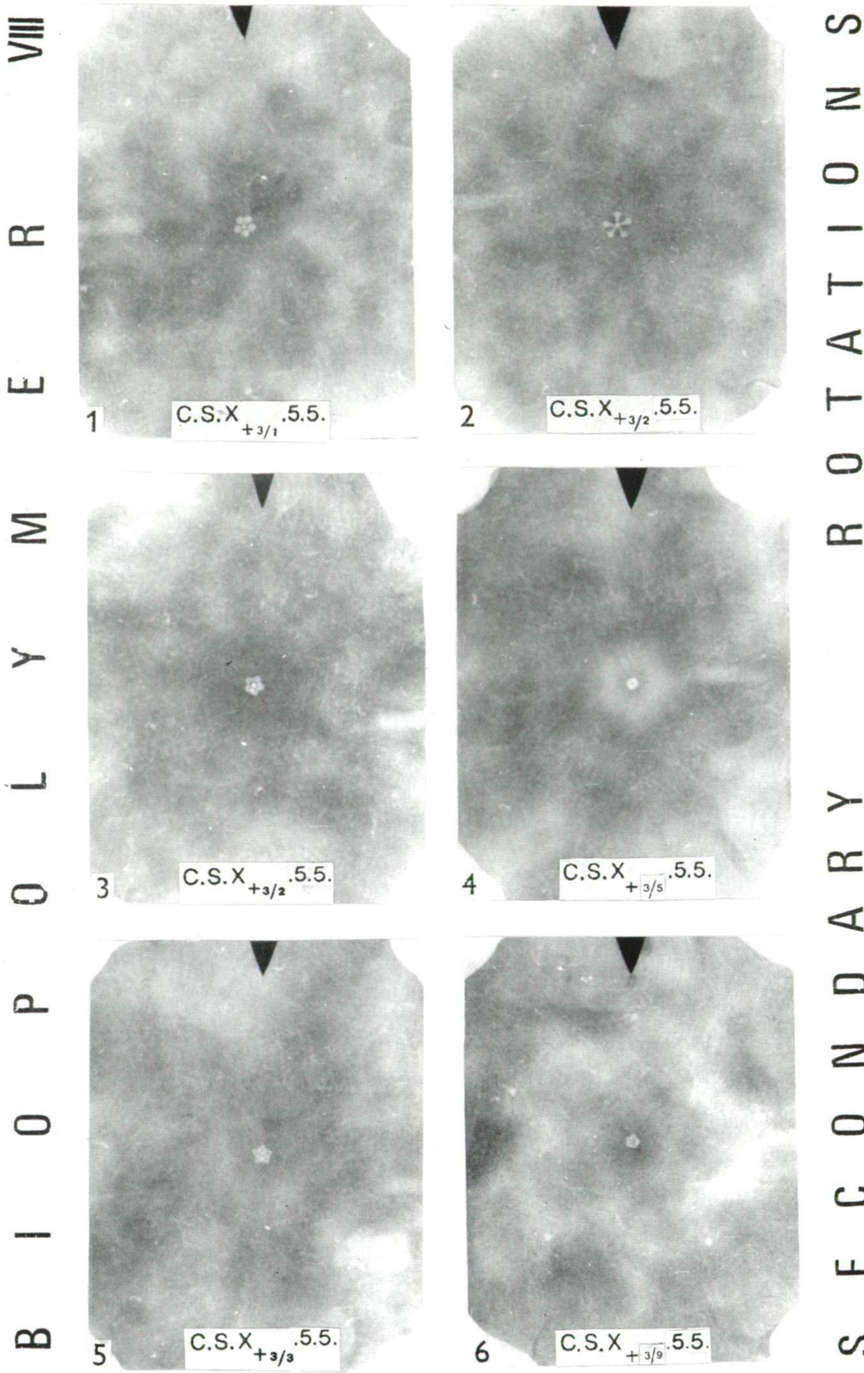
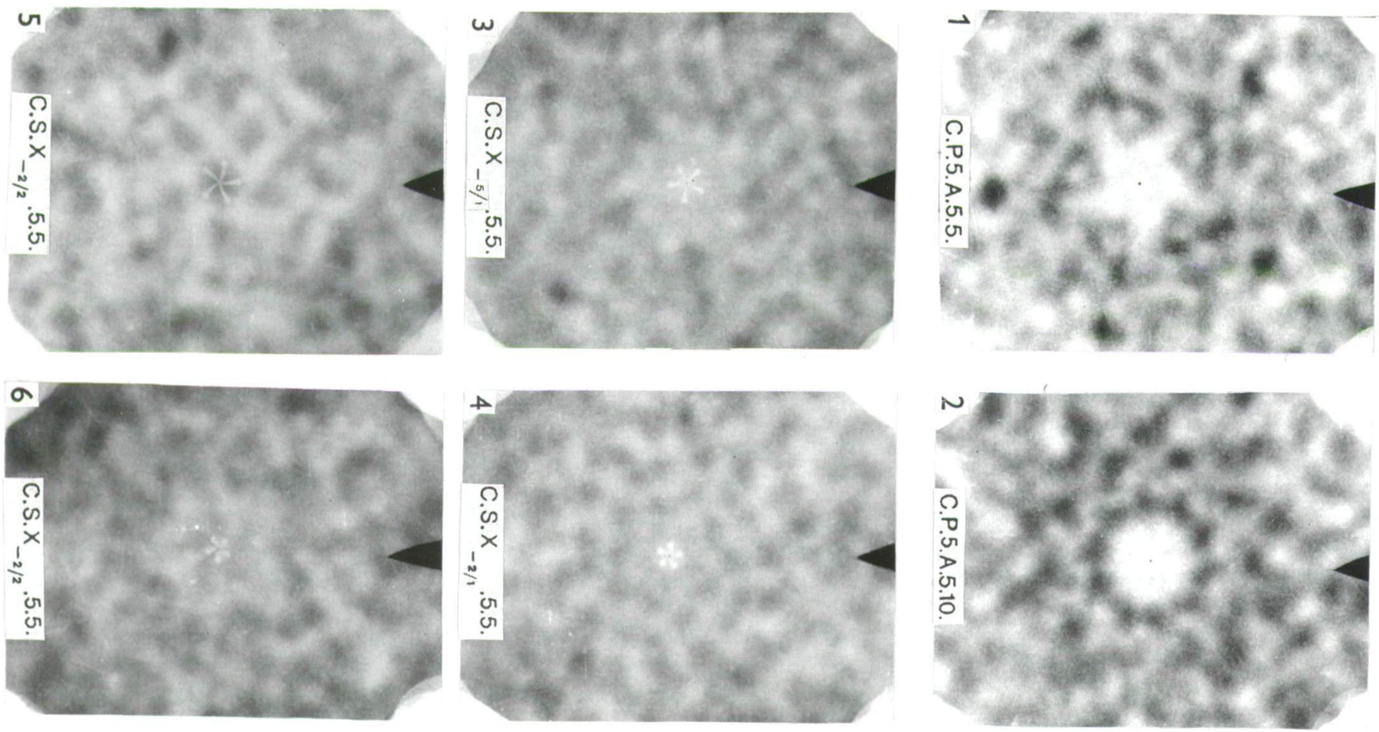

BIOPOLYMER VIII
SECONDARY ROTATIONS
1
C.S.X +3/1 .5.5.
2
C.S.X +3/2 .5.5.
3
C.S.X +3/2 .5.5.
4
C.S.X +3/5 .5.5.
5
C.S.X +3/3 .5.5.
6
C.S.X +3/9 .5.5.

Plate 3.7.

B I O P O L Y M E R IX



S E C O N D A R Y R O T A T I O N S PRIMARY ROTATIONS

Plate 3.8.

BIOPOLYMER IX

SECONDARY ROTATIONS

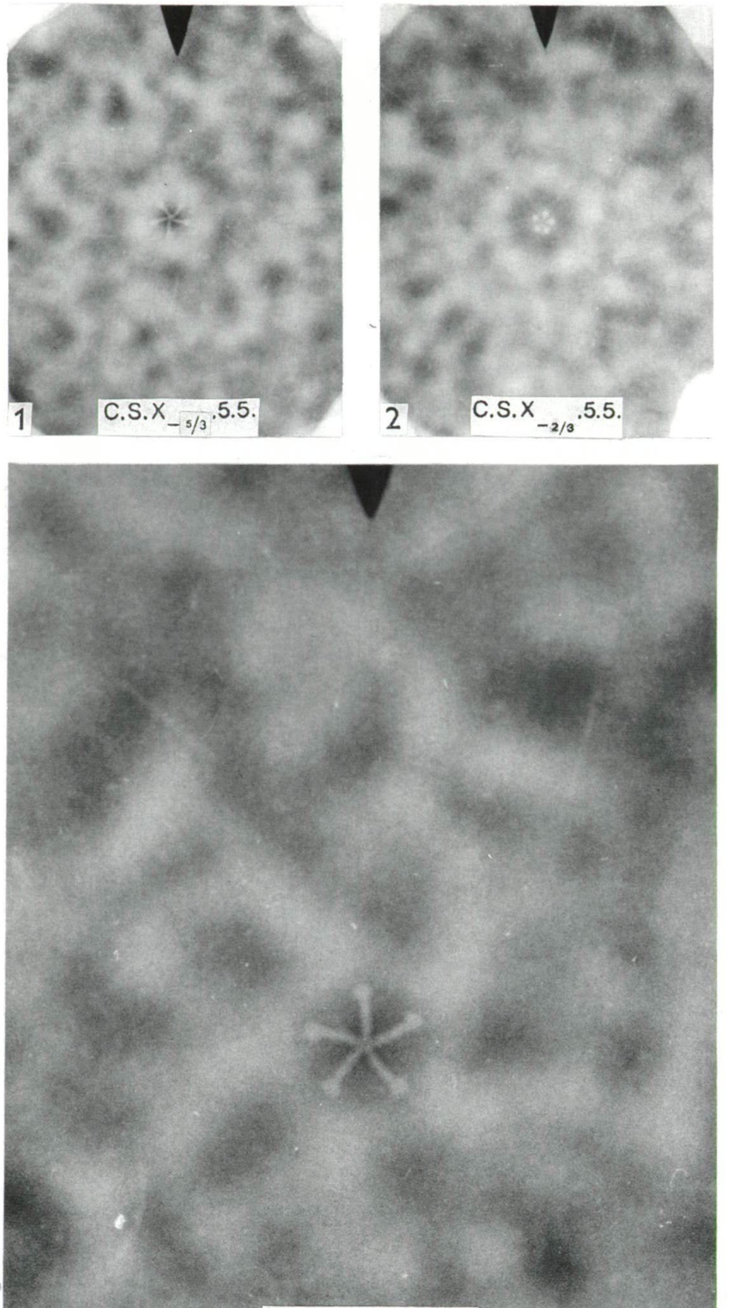


Plate 3.9.

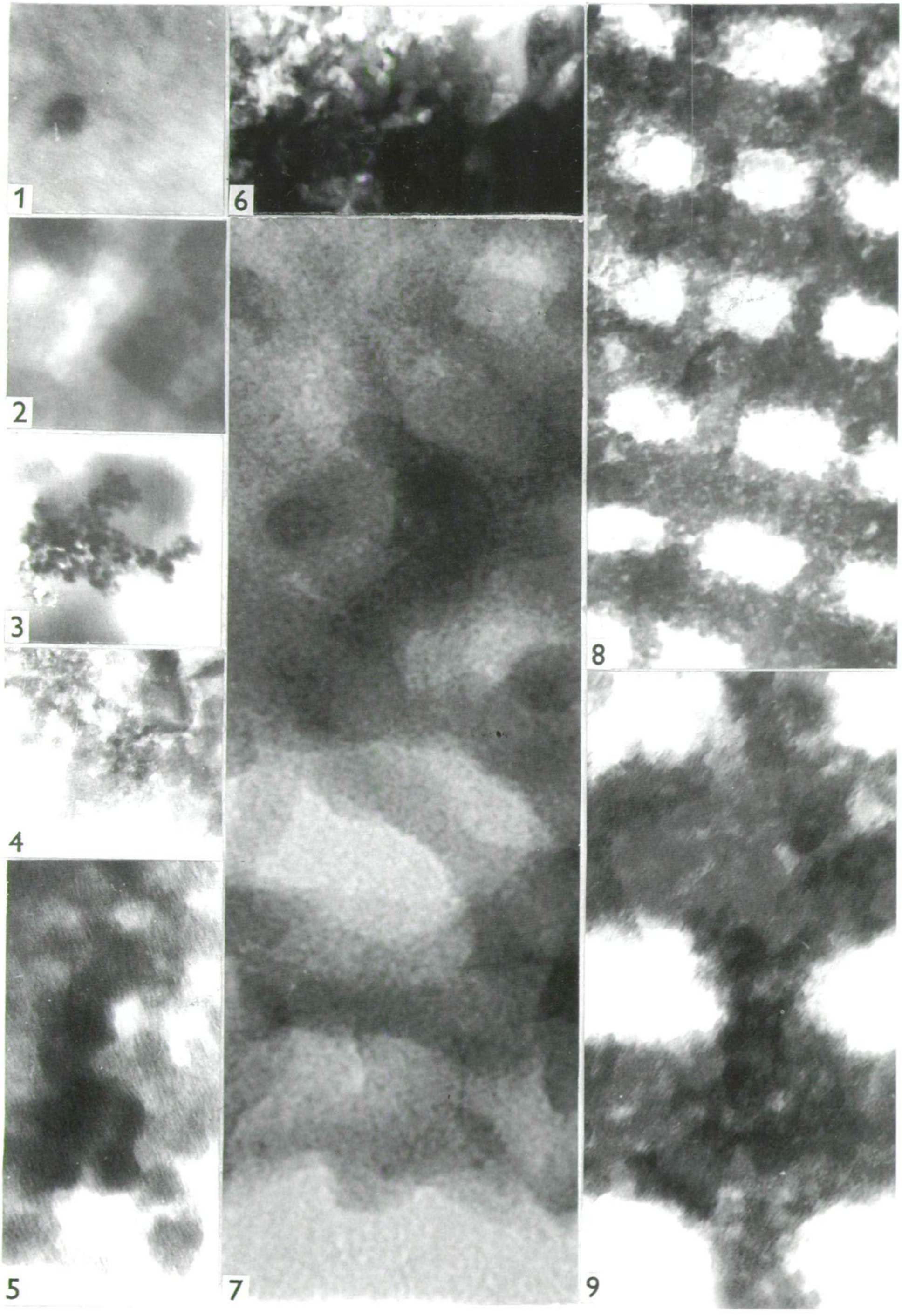


Plate 3.10.

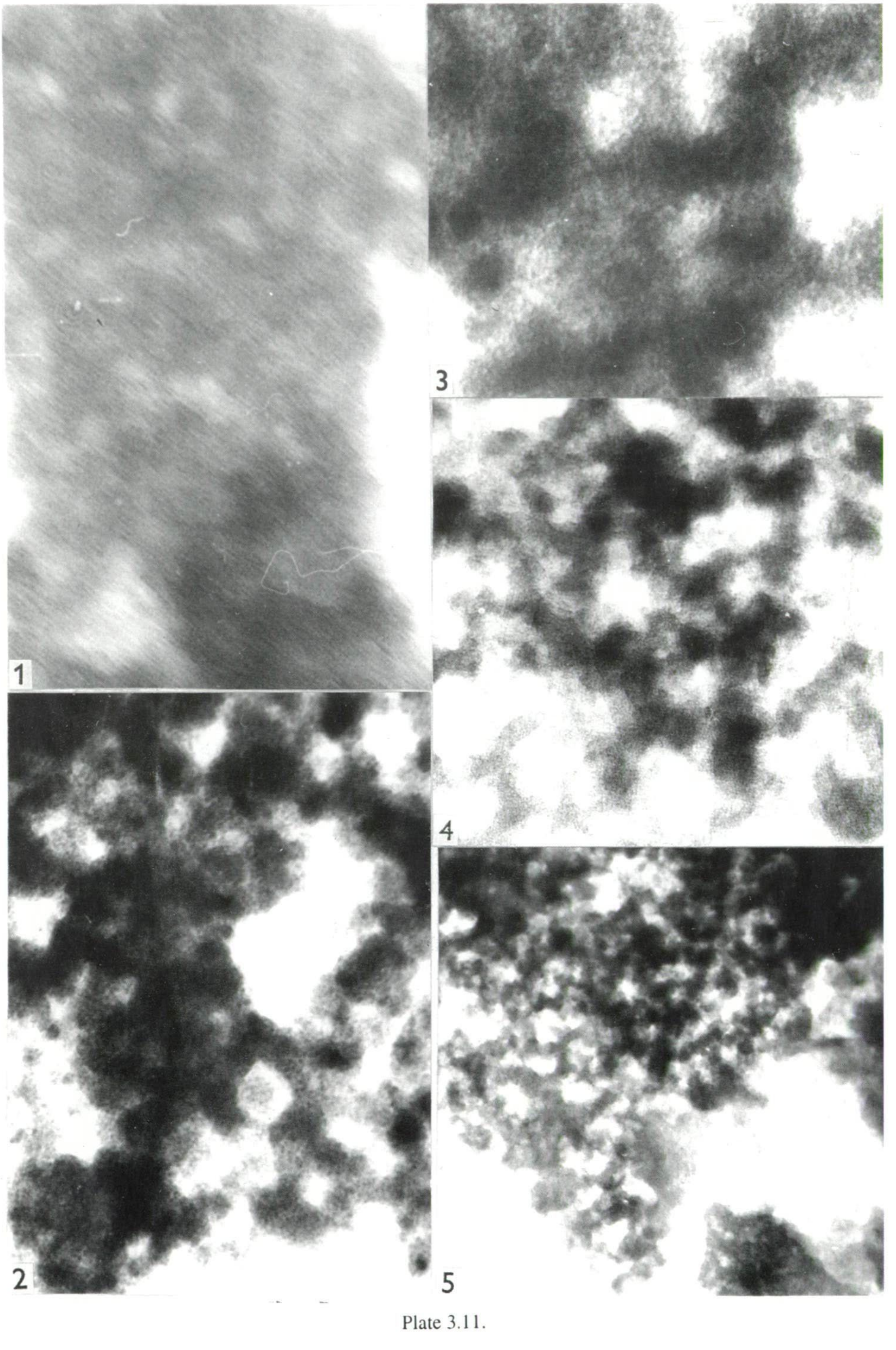


Plate 3.11.

4. BIOPOLYMER STRUCTURE AND SYMMETRY OPERATIONS IN PARTIALLY DISSOLVED AND FRAGMENTED SCLEREIDS OF ARMENIACA VULGARIS LAM.

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Abstract

In our previous paper, the methods and results of the LM investigation of the partially dissolved and fragmented sclereids of *Armeniaca vulgaris* were published. For biopolymer symmetry operations the results of experiment No: 1616 (dissolution with diethylamine, on 30 °C, during 90 days) were the best. Two pentagonal and one hexagonal biopolymer units were investigated by several kinds of symmetry operations with the modified Markham rotation method. New methods were also introduced for the investigation of the basic elements of the fullerene-like biopolymer structures.

Key words: Armeniaca vulgaris, sclereids, TEM, biopolymer symmetry.

Introduction

The first results on the TEM investigations of partially degraded and fragmented sclereids of *Armeniaca vulgaris* were published in 1991 (KEDVES, KEDVES and ROJIK) and in 1992 by KEDVES. Regular basic pentagonal polygon in Å dimension and different kinds of highly organized units (filamentous, larger globular, single compound and open polygons) were established.

Results of the TEM investigations of partially degraded sclereids were published by KEDVES and PÁRDUTZ (1992). In our previous paper (KEDVES and BORBOLA, 1997), the methods and the LM results of our long-lasting dissolution experiment were published.

This contribution presents the TEM results of partially dissolved and fragmented sclereids and in particular the results of the symmetry operations of the pentagonal and hexagonal biopolymer units.

Material and Methods

The material and the dissolution method was published in our previous paper (p. 64, 67, KEDVES and BORBOLA, 1997). One part of the partially dissolved sclereids was fragmented with a magnetic stirrer in watered medium, during 30 minutes. The fragmented sclereids were dropped on a grid covered with collodium pellicle and then dried. The electron microscopical investigatons were made an Opton EM-902 (resolution 2–3

Å) at the Hungarian Academy of Sciences Biological Research Center, EM Laboratory of the Department of Biophysics.

Results

1. Until 20 days of dissolution by both solvents (diethylamine, merkaptoethanol) the fragments were not sufficiently unfolded the biopolymer structures.

2. After 25 days of partial dissolution the larger biopolymer structures of the wall appeared. Until 8 month of dissolution different kinds of biopolymer units were observed.

3. From 9 to 12 month, the largest part of the wall components were more or less desintegrated.

4. For our biopolymer symmetry operations the results of the experiment No: 1616 (dissolution with diethylamine, temperature: 30 °C, length of time: 90 days) were the best. Two regular pentagonal (Plate 4.1.), and one hexagonal (Plate 4.2.) biopolymer unit was chosen for symmetry operations.

BIOPOLYMER I

(Plate 4.1., plate 4.3., figs. 1–6, plate 4.4., figs. 1,2)

Primary rotations

C.P.5.A.5.5. (Plate 4.3., fig. 1)

Around the basic pentagon several light and dark points of symmetries appeared, forming further larger regular pentagons. The outermost rotation area is more or less pentagonal star form.

C.P.5.A.5.10. (Plate 4.3., fig. 2)

The secondary points of symmetry are not so well expressed. But around the light rotation centrum it is a dark circle, bordered with ten points of symmetry. These points of symmetry are continued by radially oriented dark fields. The rotation area is characteristic.

Secondary rotations

C.S.$X_{+1/2}$.5.5. – C.P.5.A.5.5. (Plate 4.3., fig. 3)

A very characteristic light star forming field appeared after this rotation. This star is surrounded by narrow light arched fields forming a more or less complete circle. In this way five dark points of symmetry can be recognized within this light circle.

C.S.$X_{+1/5}$.5.5. – C.P.5.A.5.5. (Plate 4.3., fig. 5)

Around the rotation centrum there are five dark points of symmetry in a light not completely regular light pentagonal fields. Sometimes the apices of the pentagon are slightly bifurcated. This light rotation area is embedded in a dark field.

C.S.$X_{-2/1}$.5.5. – C.P.5.A.5.5. (Plate 4.4., fig. 1)

The negative secondary rotation centrum resulted in five dark points of symmetry forming a regular pentagon. This is surrounded by another well defined pentagon of five light points. Around this pentagon further dark and light points of symmetry can be recognized but its distribution is not so regular.

C.S.$X_{+1/6}$.5.10. – C.P.5.A.5.10. (Plate 4.3., fig. 4)

This kind of secondary rotation resulted in dark and light points of symmetry which form regular pentagons around the centrum of the rotation. It is a characteristic light rotation area. Around this area there are further dark points of symmetry.

C.S.$X_{+1/8}$.5.10. – C.P.5.A.5.10. (Plate 4.3., fig. 6)

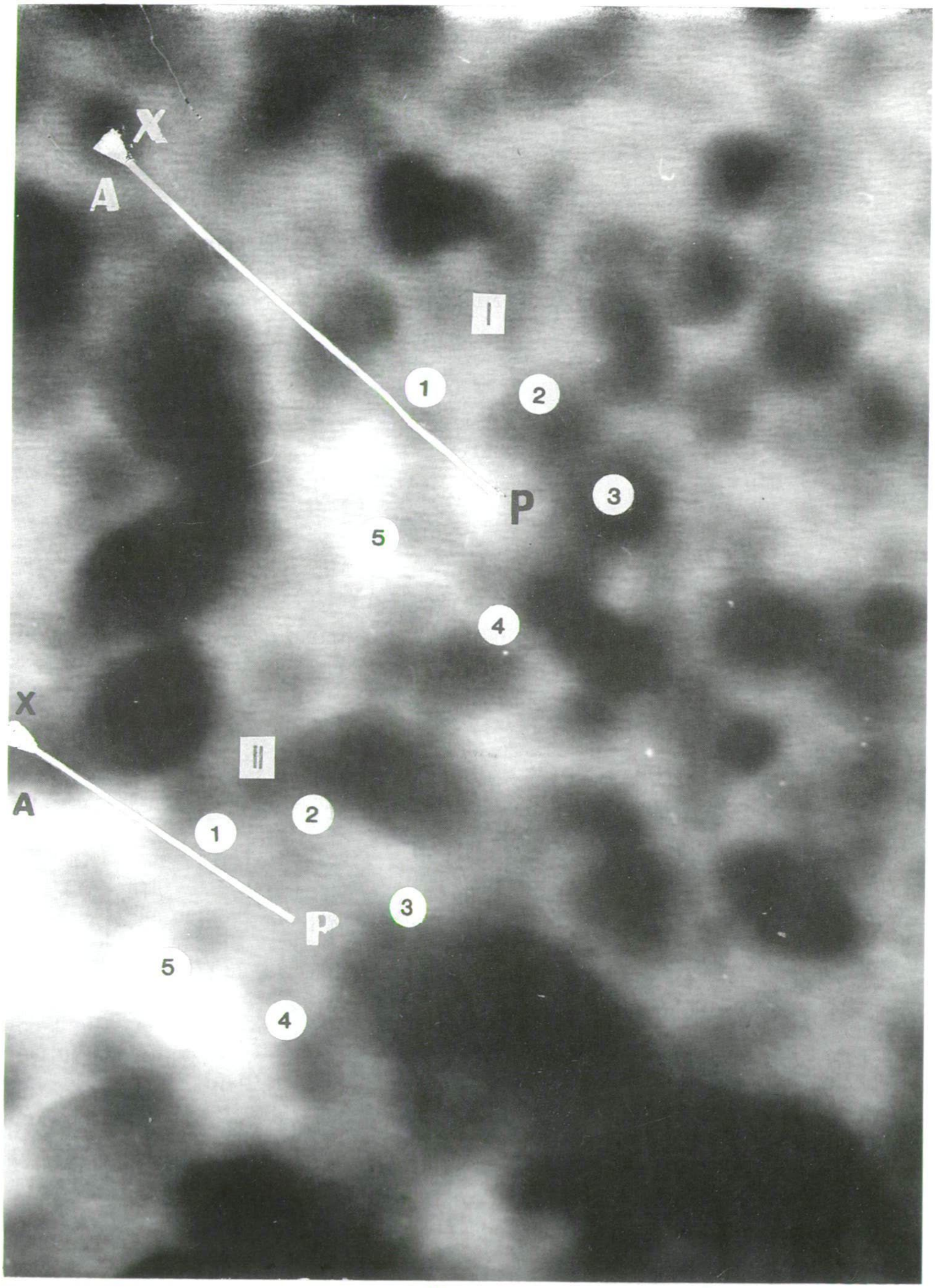

Plate 4.1.

TEM picture of the partially degraded sclereids of *Armeniaca vulgaris* LAM. Experiment No: 1616. The investigated pentagonal biopolymer units are indicated. Negative no: 3182, 1.000.000x.

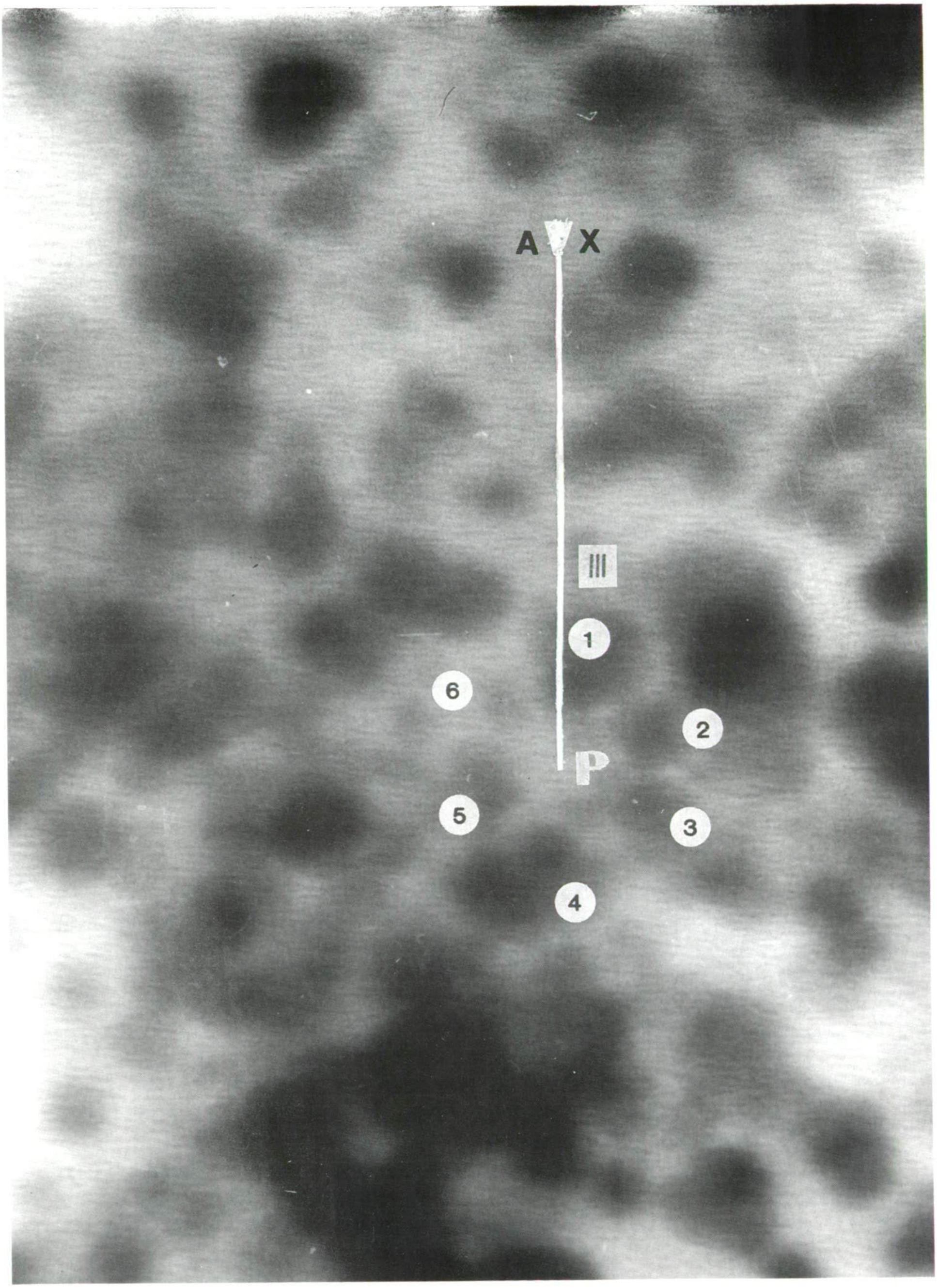

Plate 4.2.

TEM picture of the partially degraded sclereids of *Armeniaca vulgaris* LAM. Experiment No: 1616. The investigated hexagonal biopolymer unit is indicated. Negative no: 3182, 1.000.000x.

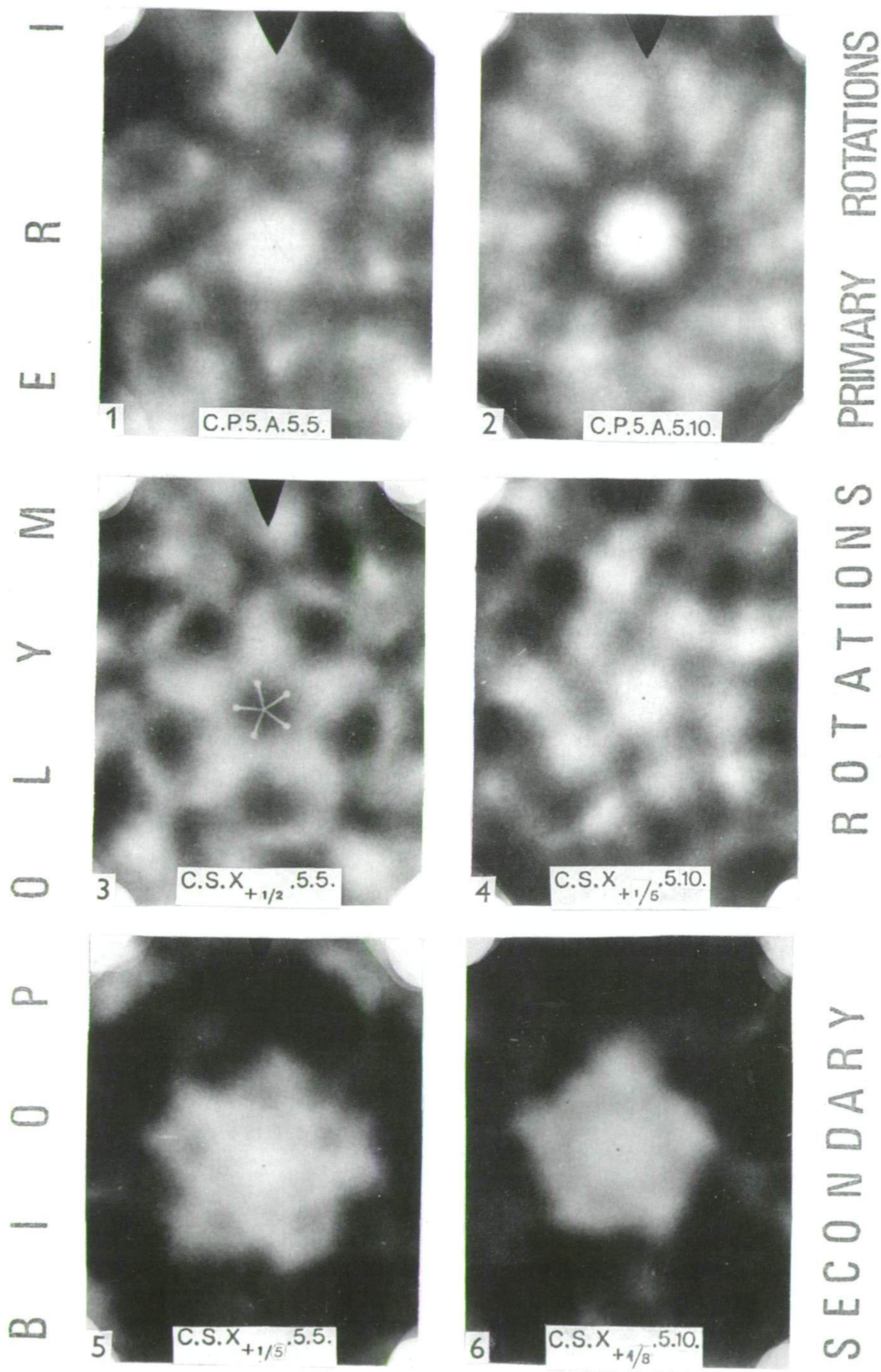

Plate 4.3.

Biopolymer I
1. Five-fold primary rotation picture. 500.000x.
2. Ten-fold primary rotation picture. 500.000x.
3–6. Secondary rotation pictures. 500.000x.

A light, pentagonal area appeared in a dark field. This is similar to the secondary rotation picture illustrated in Plate 4.3., fig. 5. In this case the not wholly discovered molecular system of the rotation centrum is the reason of this result.

C.S.$X_{-2/9}$.5.10. – C.P.5.A.5.10. (Plate 4.4., fig. 2)

Similarly to the previous rotation a light pentagonal field appeared after this kind of rotation. This light field is surrounded by a dark pentagon. There are more or less radially oriented light bands rectangular to the sides of the light pentagon. Probably these light bands surround larger, dark biopolymer units.

BIOPOLYMER II

(Plate 4.1., plate 4.4., figs. 3–6, plate 4.5., figs. 1–4)

Primary rotations

C.P.5.A.5.5. (Plate 4.4., fig. 3)

The dark pentagonal unit is surrounded by a light pentagon. But between two larger light points of symmetry there are further not so characteristic light points of symmetry. In this way there is a more or less circular light field around the centrum of the rotation. There are more or less radially oriented light points of symmetry coming from the larger points of symmetry of the light pentagon.

C.P.5.A.5.10. (Plate 4.4., fig. 4)

Ten, not so characteristic dark points of symmetry appeared which are surrounded by further ten light points of symmetry, and so it is a very characteristic spherical light field. This is surrounded by further ten dark points. Finally ten more or less characteristic light radially oriented further light points.

Secondary rotations

C.S.$X_{-1/1}$.5.5. – C.P.5.A.5.5. (Plate 4.4., fig. 5)

The central pentagon of dark points of symmetry is followed by another pentagon of light points. This is surrounded by another larger pentagon, but towards the edges there are two larger dark points.

C.S.$X_{-1/2}$.5.5. – C.P.5.A.5.5. (Plate 4.5., fig. 1)

In a light pentagonal field a not so characteristic dark star appeared. The light pentagonal field is surrounded by a characteristic dark pentagon. Around this there are five large points of symmetry forming another pentagon.

C.S.$X_{-1/3}$.5.5. – C.P.5.A.5.5. (Plate 4.5., fig. 3)

A pentagon appeared after this rotation. The apices of this pentagon continue by a radially oriented system of dark lines, which delineate supplementary light fields. There is a circular light rotation area with small ten angles in a dark basic field.

C.S.$X_{+2/2}$.5.10. – C.P.5.A.5.10. (Plate 4.4., fig. 6)

This secondary rotation resulted in a central dark star-shaped pentagon. This is encircled by a light-star, but the apices of this latter one are ramifying. Five large dark points are around the light star-shape regular pentagon.

C.S.$X_{+2/3}$.5.10. – C.P.5.A.5.10. (Plate 4.5., fig. 2)

A dark regular pentagon appeared after this rotation. This is surrounded by a light pentagon of ramifying apices. Five large dark points are around this rotation area.

C.S.$X_{+2/4}$.5.10. – C.P.5.A.5.10. (Plate 4.5., fig. 4)

A small dark area appeared near the rotation centrum. This is surrounded by a light pentagonal field. Further light areas of irregular shape coming from the sides of the pentagon represent another, outest rotation area.

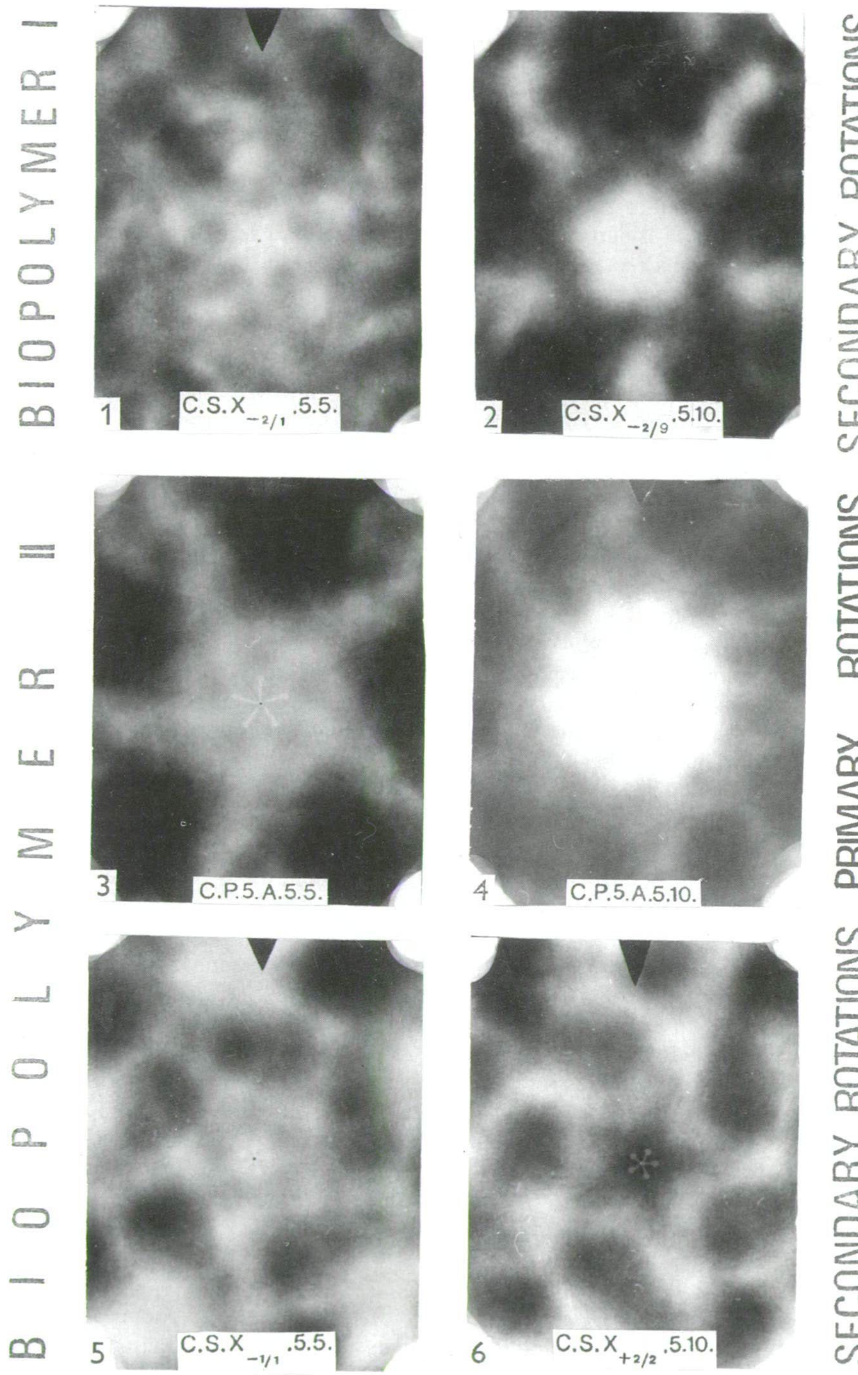

Plate 4.4.

Biopolymer I
1,2. Secondary rotation pictures. 500.000x.

Biopolymer II
3. Five-fold primary rotation picture. 500.000x.
4. Ten-fold primary rotation picture. 500.000x.
5,6. Secondary rotation pictures. 500.000x.

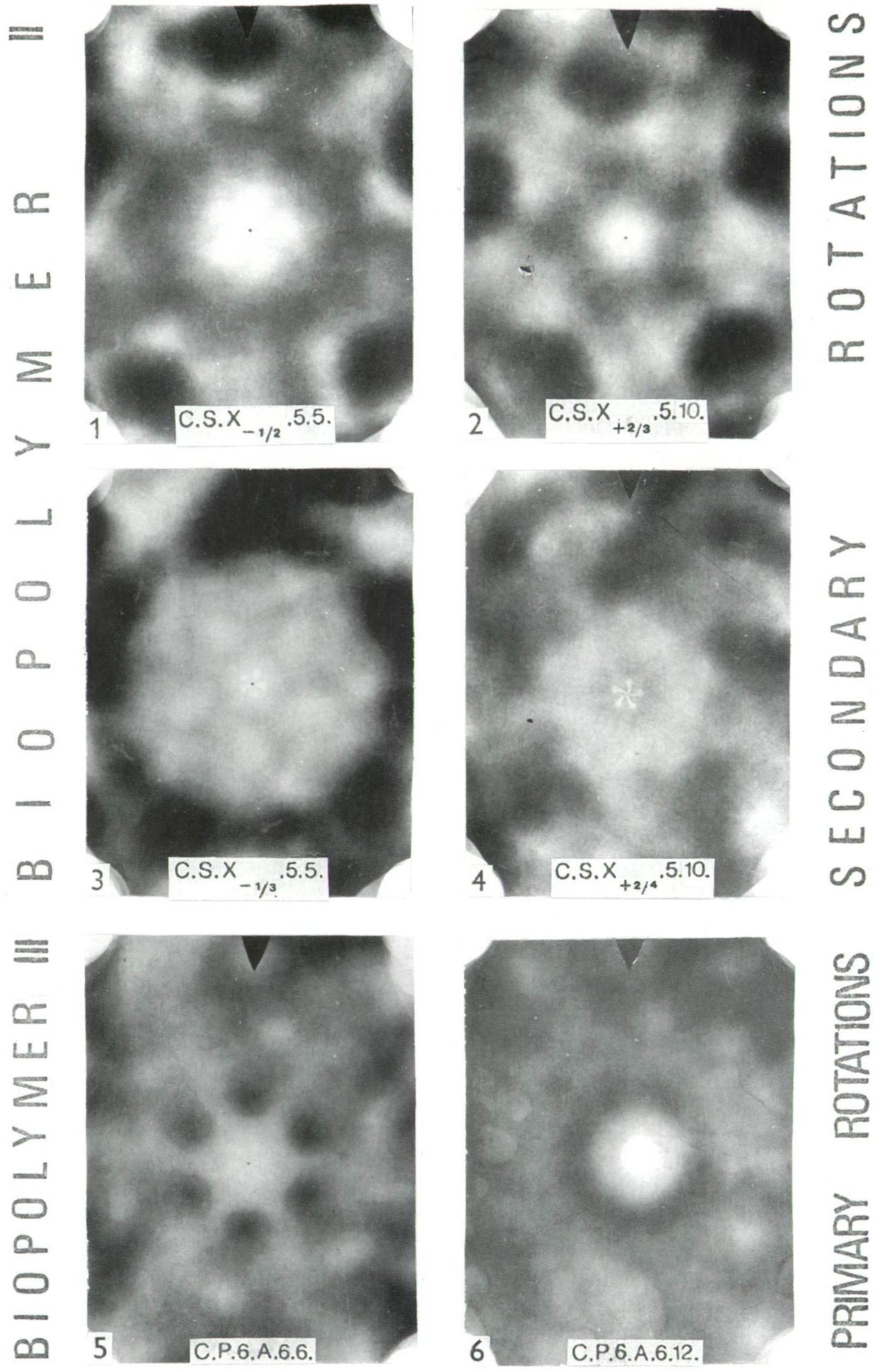

Plate 4.5.

Biopolymer II

1–4. Secondary rotation pictures. 500.000x.

Biopolymer III

5. Six-fold primary rotation picture. 500.000x.
6. Twelwe-fold primary rotation picture. 500.000x.

BIOPOLYMER III

(Plate 4.2., plate 4.5., figs. 5,6, plate 4,6., figs. 1,2, plate 4.7., figs. 1–6)

In contrast to the previous ones this biopolymer unit is hexagonal and not pentagonal.

Primary rotations

C.P.6.A.6.6. (Plate 4.5., fig. 5)

This rotation reinforced the hexagonal biopolymer system. Not so characteristic, further points of symmetry appeared forming a nearly circular light rotation area, with further light ramifications.

C.P.6.A.6.12. (Plate 4.5., fig. 6)

Light and dark concentric zones appeared after this rotation. The points of symmetry are not well expressed. The outer rotation area is more or less circular.

Incomplete rotations

I.P.6.A.6.$3_{1,3,5}$ (Plate 4.6., fig. 1)

It is interesting that after this incomplete three-fold rotation all six points of the biopolymer unit appeared. Further points of symmetry appeared with further more or less network-like points of symmetry.

I.P.6.A.$3_{2,4,6}$ (Plate 4.6., fig. 2)

This incomplete rotation resulted essentially in those of the previous one.

TICOS polyhedra rotations of the hexagonal biopolymer unit

This kind of rotation was used only once (KEDVES, 1991).

C.P.$_{4,6}$.4.A.4.4. (Plate 4.7., fig. 1)

After this rotation the secondary points of symmetry represent three tetragons, in two areas. The inner one is more or less rhombus-like oriented in the rotation axis. The other is a tetragon perpendicular to the rotation axis. The outer rhombus is composed of large points of symmetry obliquely to the rotation axis.

C.P.$_{-5}$.0.-A.5.5. (Plate 4.7., fig. 3)

This rotation resulted in an inner opposite pentagon, and further larger points of symmetry of one pentagon.

C.P.$_{4,6}$.5.A.5.5. (Plate 4.7., fig. 5)

The points of symmetry and the pentagonal areas are oblique to the rotation axis.

New method of rotation in the investigation of the fullerene-like biopolymer structures

In this case an attempt was made to establish a method for the connection of the hexagonal and pentagonal biopolymer organizations. This is essentially a peculiar radial rotation. The axis of the rotation is a linear feature between the centre of the hexagonal biopolymer unit and the mid-point of the side of the hexagon. The rotation centrum was indicated as follows. Perpendicular to the sides of the hexagon the rotation centrum was measured to the rotation axis, this is the half size of the diameter of the regular pentagonal unit. After this a fivefold rotation was made. In this paper three such kinds of rotation are presented.

C.H.5_0.R.$6_{1,2}$.5.5. (Plate 4.7., fig. 2)

This rotation resulted in a dark more or less pentagonal field. This field is surrounded by a light area. There are further light lines originating from this light zone.

C.H.5_0.R.$6_{2,3}$.5.5. (Plate 4.7., fig. 4)

A regular dark pentagonal unit appeared after this rotation, together with further points of symmetry. This may be one connected element to the hexagonal biopolymer system.

C.H.5_0.R.$6_{3,4}$.5.5. (Plate 4.7., fig. 6)

This rotation resulted also in a regular pentagon, but this is a little larger than the previous one. Further points of symmetry appeared as well.

Discussion and Conclusions

The long-lasting partially dissolved sclereids of *Armeniaca vulgaris* with diethylamine and merkaptoethanol unfolded step by step by the length of time the biopolymer structure of the wall. Regular pentagonal and hexagonal basic units were established. The primary and the secondary rotations of the regular pentagonal biopolymer unit verified again the presence of the quasi-periodic lattice. But there are several new data on further kinds of biopolymer structures.

We payed peculiar attention to the hexagonal biopolymer unit in our material by the following methods:

1. We tryed the so-called TICOS polyhedra method (KEDVES, 1991b) to establish whether it is a real hexagon or two regular pentagon is in a peculiar opposite position. The results of these rotations are not convincing.

2. After this we started to elaborate a new method on the hypothesis that this regular hexagon is a structural element of a fullerene-like – quasi-equivalent – organization. The starting point of this method is that there are regular pentagons around this hexagon. Based on our first results using this recently elaborated method the hypothetical regular pentagon units were verified.

In summary we hope that with these data we advanced towards a better knowledge of this peculiar biological organization. As it was emphasized in several previous papers in the future the destabilized quasi-periodic biological structures of the oil shale or of the sclereids or other plant cell wall may be a new energy basis of environmental protective character.

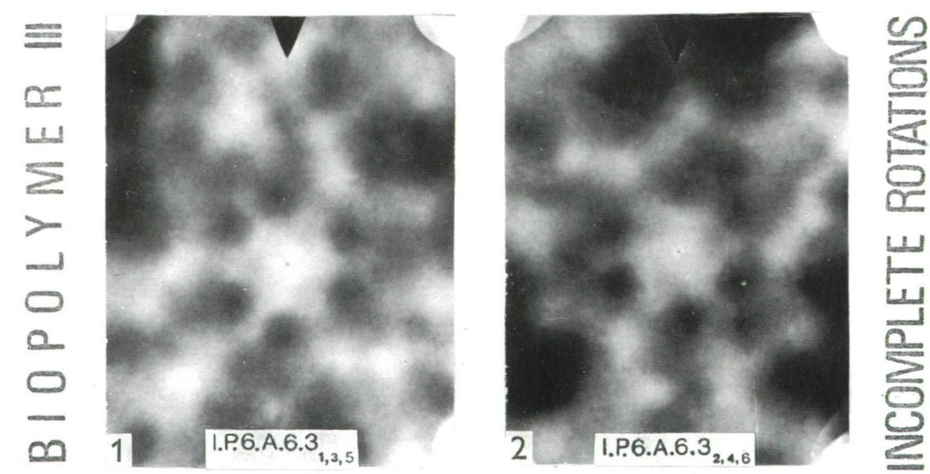

Plate 4.6.

Biopolymer III

1,2. Incomplete rotation pictures. 500.000x.

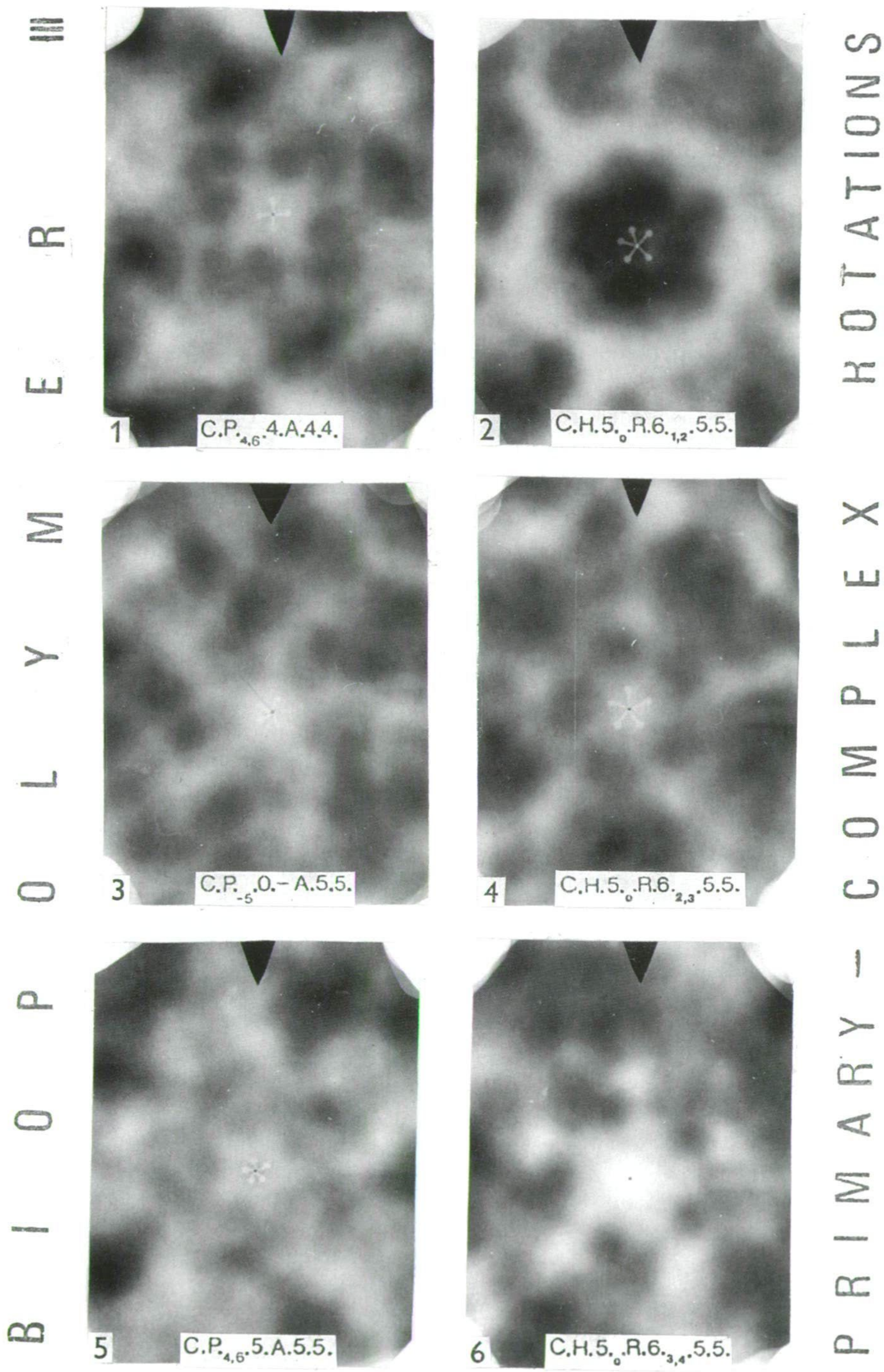

Plate 4.7.

1,3,5. TICOS modelling rotation pictures. 500.000x.
2,4,6. Complex rotation pictures. 500.000x.

Acknowledgements

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5. LM INVESTIGATIONS OF PARTIALLY DISSOLVED SPOROMORPHS II.

KEDVES, M., HORVÁTH, E., MÉSZÁROS, E., MÉSZÁROS, R., RONTÓ, G., SZLÁVIK, N., GAUDÉNYI, SZ. and KALMÁR, Á.

Cell Biological and Evolutionary Micropaleontological Laboratory of the Department of Botany of the J. A. University, H-6701, P. O. Box 993, Szeged, Hungary

Abstract

This contribution presents LM results of partially dissolved pollen grains of the following species: *Larix decidua* MILL., *Thalictrum minus* L., *Platanus hybrida* BROT., *Tilia platyphyllos* SCOP. and *Castanea sativa* MILL. Diethylamine, merkaptoethanol, methanol, ethanol, n-propanol, n-butanol and i-amyl alcohol were used as solvents at 30 °C, during 30, 90, 150, 210, 270 and 330 days. The Duhoux-effect was observed at the pollen grains of *Larix decidua* MILL. The sporopollenin of the ectexines of *Platanus* hybrida and Tilia platyphyllos were the less resistant to the influence of diethylamine. But not so important qualitative alterations were observed at the investigated *angiosperm* pollen grains. Worth of mentioning is the resistance of the exine of *Castanea sativa* in contrast to the less resistant exine of the genus *Quercus*. The variation of the size was statistically investigated at the pollen grains of *Platanus hybrida*, the peculiar alterations of the pollen grains of *Larix decidua*, finally the pollen tube development at *Tilia platyphyllos*.

Key words: Palynology, recent, pollen grains, partial dissolution, LM method.

Introduction

In our previous paper (KEDVES, KÁROSSY and BORBOLA, 1997) we summarized the problems and our previous results within this research program of the Laboratory. This contribution is part of this research program. The species chosed are in relation with the problems which emerged in connection with to the previous results.

Materials and Methods

Pollen grains of the following species were the subject of our investigations.

Larix decidua MILL.

Locality: Botanical Garden of the J. A. University. Collected: Á. ERDŐDI, on 16.04.1996. Beginning of the experiments: 18.04.1996. Numbers of experiments: 1/7-368-409.

Thalictrum minus L.

Locality: Botanical Garden of the J. A. University. Collected: Á. ERDŐDI, on 12.06.1996. Beginning of the experiments: 13.06.1996. Numbers of experiments: 1/7-521-563.

Platanus hybrida BROT.

Locality: Botanical Garden of the J. A. University, Collected: Á. ERDŐDI, on 30.04.1996. Beginning of the experiments: 02.05.1996. Numbers of experiments 1/7-430-477.

Tilia platyphyllos SCOP.

Locality: Botanical Garden of the J. A. University, Collected: Á. ERDŐDI, on 01.06.1996. Beginning of the experiments: 06.06.1996. Numbers of experiments 1/7-479-520.

Castanea sativa MILL.

Locality: Botanical Garden of the J. A. University, Collected: Á. Erdődi, on 14.06.1996. Beginning of the experiments: 18.06.1996. 1/7-571-612.

The method is completely identical with the earlier one but we repeat it. (P.45)

"5 mg dried spore or pollen material was measured into small glasses. 5 ml H_2O distilled and 0.2 ml diethylamin or merkaptoethanol were added to the dried experimental material. Other alcohols: methanol, ethanol, etc. 5 ml was added to 5 mg spore or pollen material. Temperature: 30 °C."

It's easy to find all data of experiments in Plate 5.1–5.5.

Results

Larix decidua MILL. (Plate 5.1., figs. 1–42, Table 5.1)

Very characteristic Duhoux-effect was observed during the light microscopical investigations. The pollen grains were classified into three groups. (Table 5.1)

1: qualitatively non-altered pollen grains (Plate 5.1., fig. 1),

2: The so-called "hiatus group" (Plate 5.1., fig. 14),

3: Ectexine-lost pollen grains (Plate 5.1., fig. 12).

After thirty days the *"hiatus forms"* occurred in an important quantity and their proportion more or less regularly increased. But the quantities of the ectexine-lost pollen grains changed irregularly in the relation of time and organic solvents.

Thalictrum minus L. (Plate 5.2., figs. 1–42)

No important alterations were observed. Sometimes minor alterations are in the sizes and the thickness of the ectexine.

Platanus hybrida BROT. (Plate 5.3., figs. 1–38, Table 5.2)

The diethylamine dissolved the ectexine relatively quickly. We investigated in detail the alteration of size of the pollen grains. Table 5.2 illustrates well that there is a great variety in the diameter of the pollen grains by the different solvents and the length of time of the dissolution.

Tilia platyphyllos SCOP. (Plate 5.4., figs. 1–37, Table 5.3)

Within the recently investigated species the ectexine of *Tilia platyphyllos* is the less resistant to diethylamine. We have observed a remarkable variation in the diameter of the pollen grains during the qualitative investigations. The pollen tube development indiced by the organic solvents was also investigated. Table 5.3. summarizes these results. In this case also three groups were established.

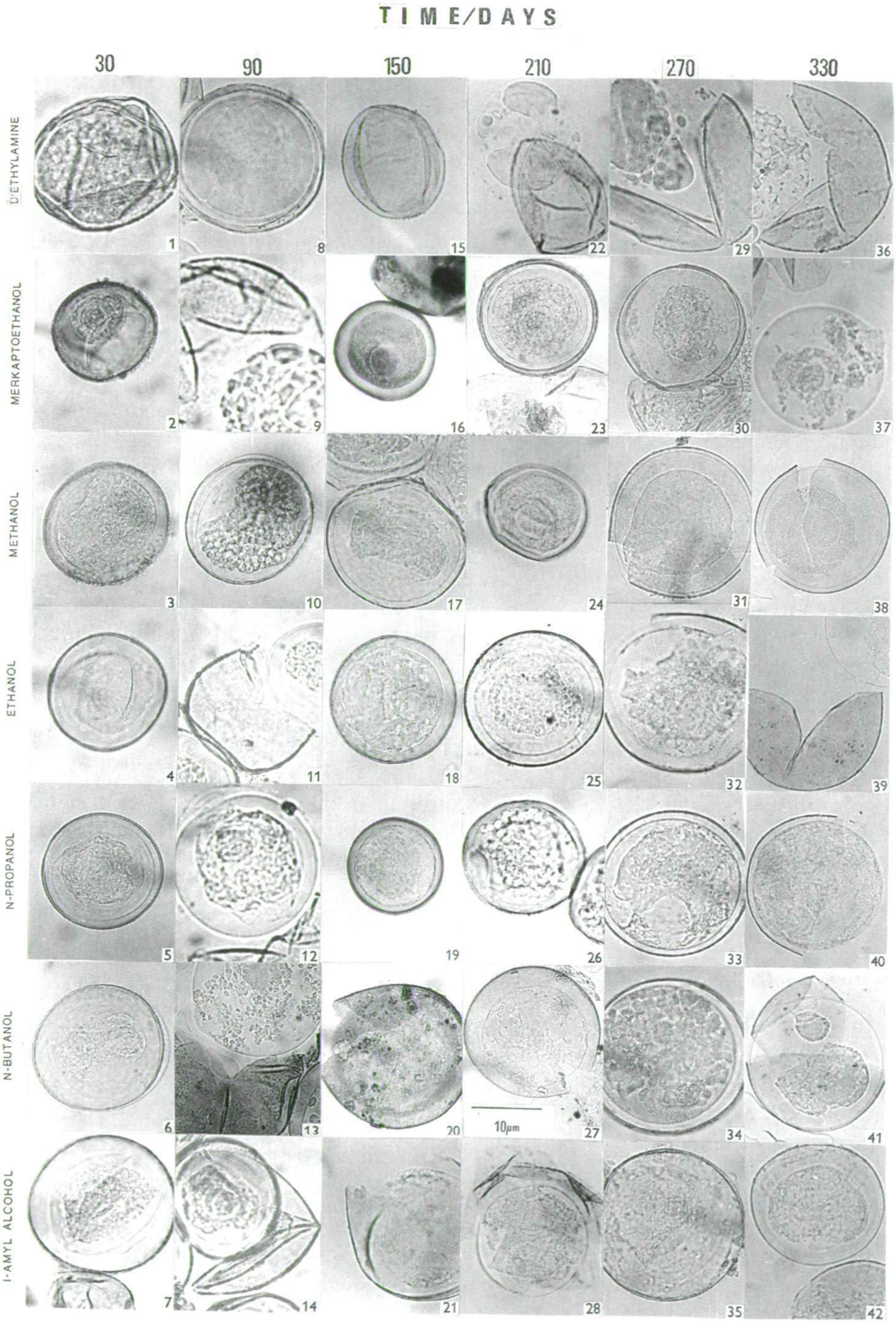

Plate 5.1., 1–42. *Larix decidua* MILL.

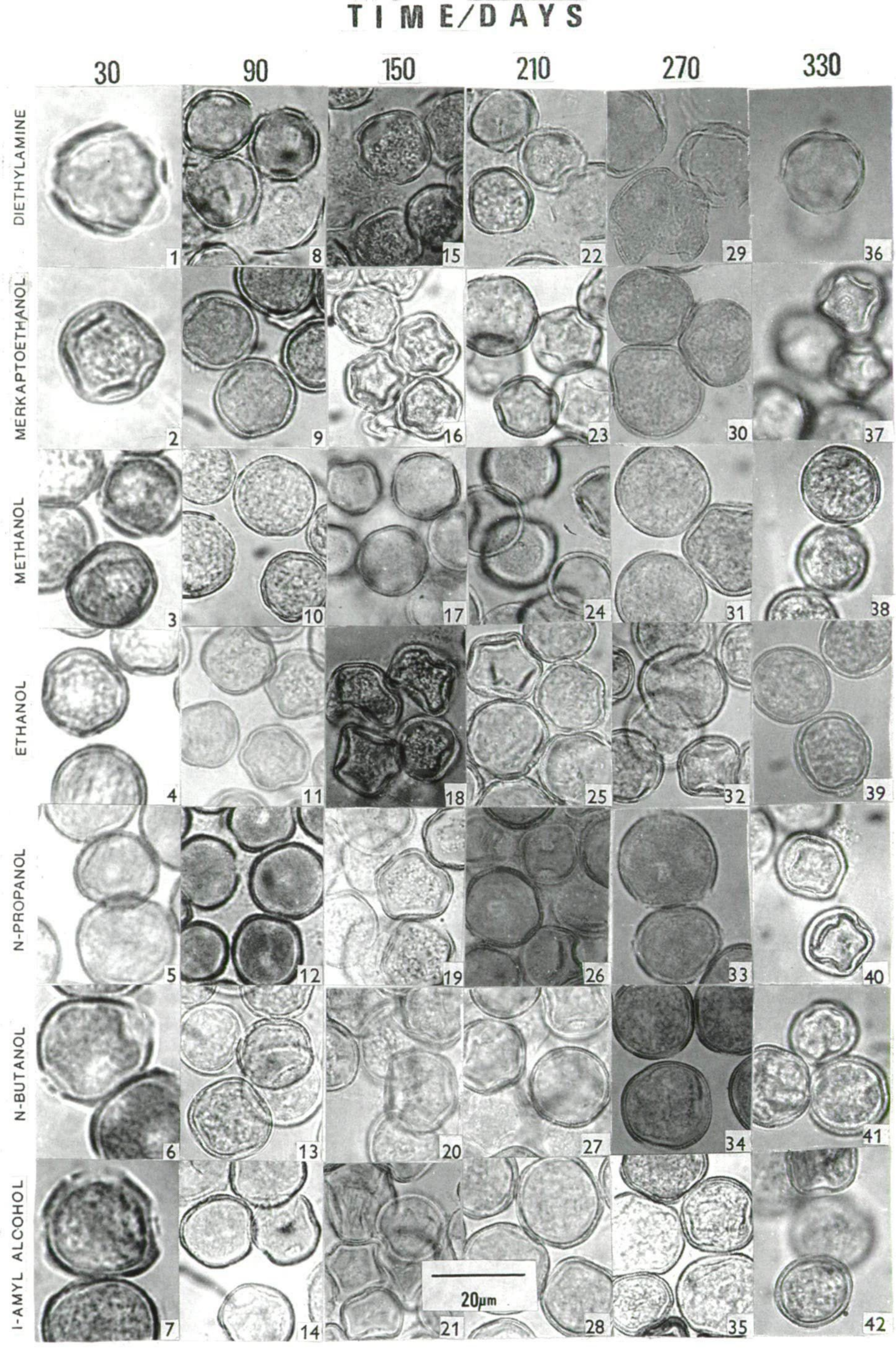

Plate 5.2., 1–42. *Thalictrum minus* L.

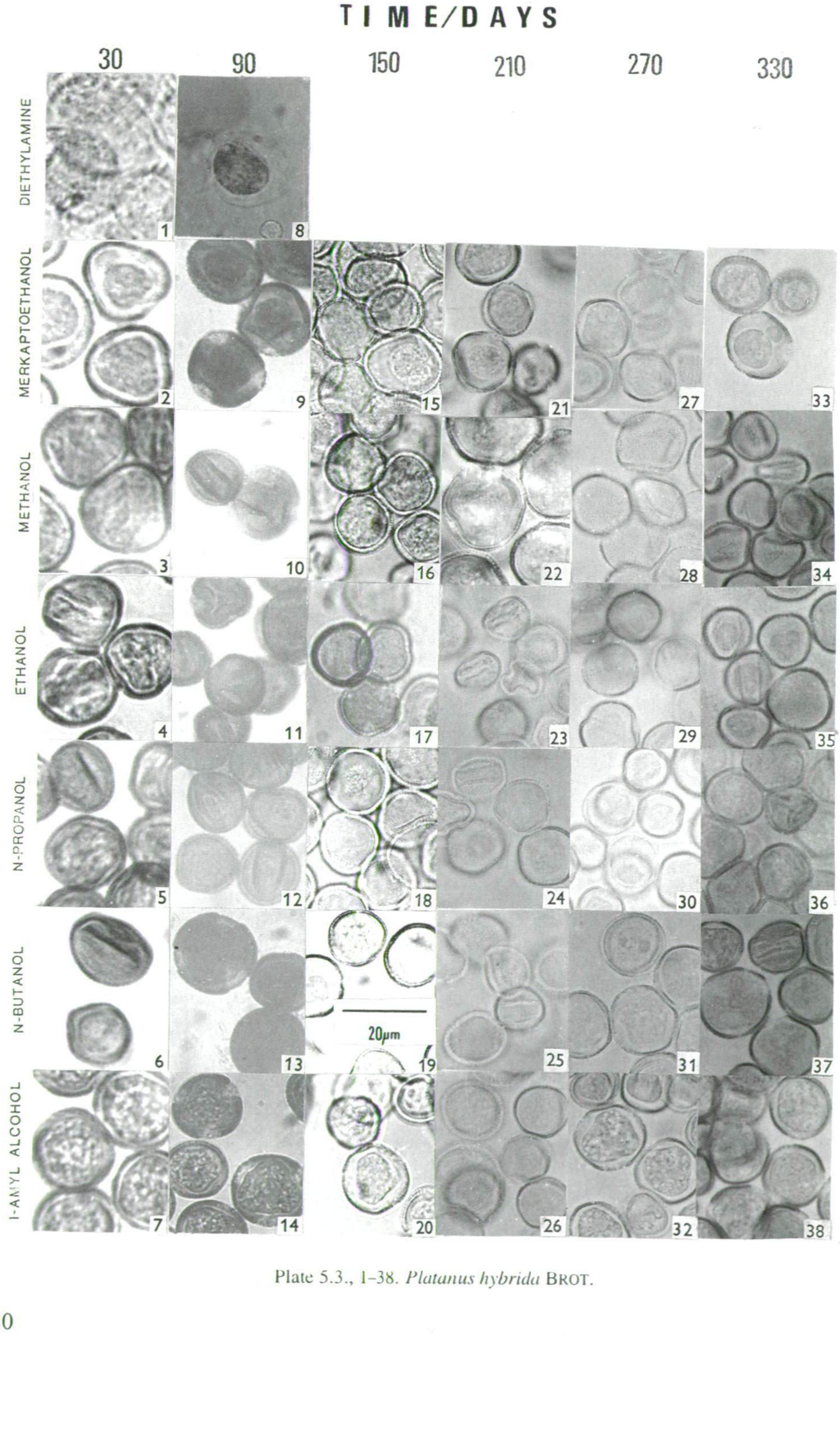

Plate 5.3., 1–38. *Platanus hybrida* BROT.

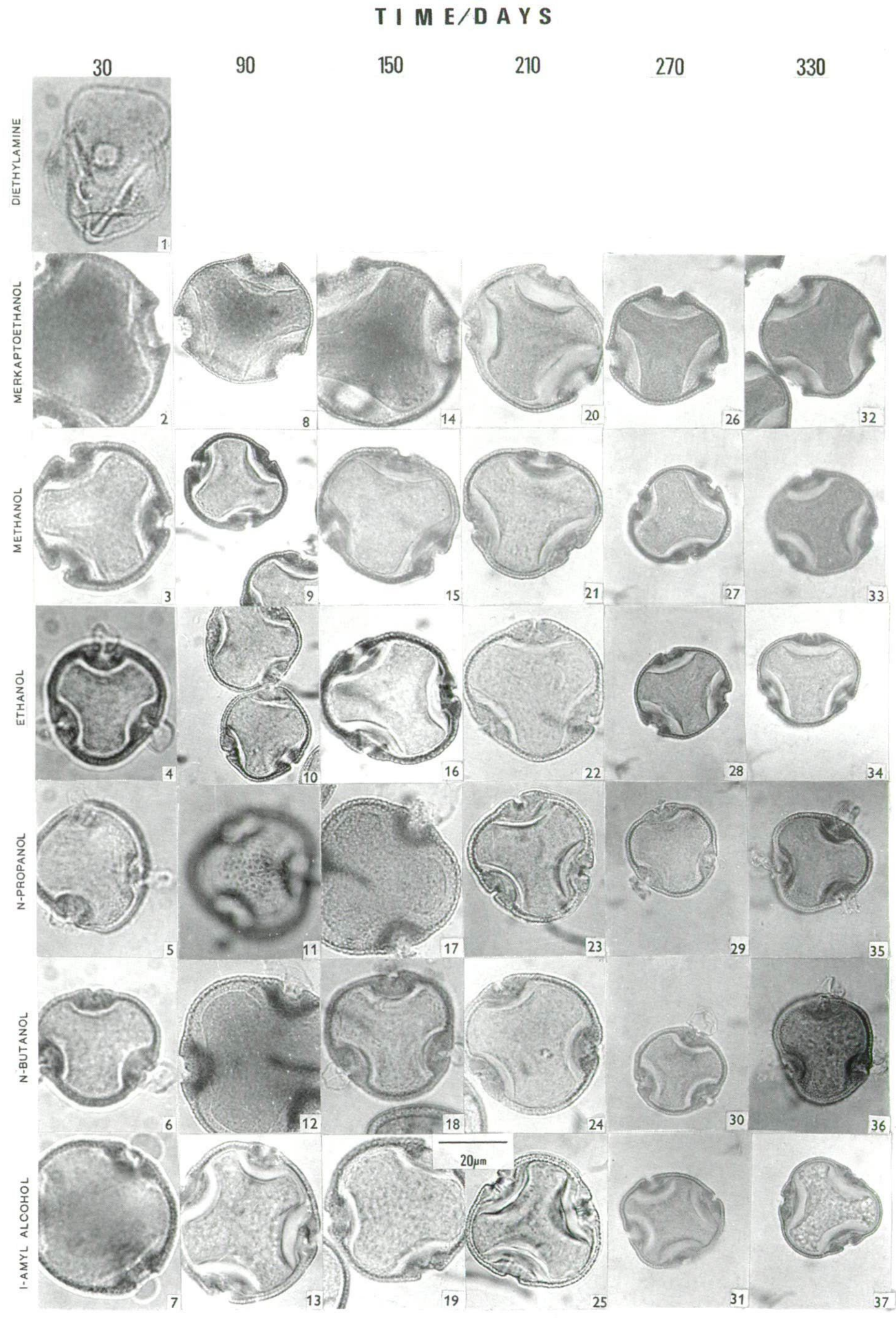

Plate 5.4., 1–37. *Tilia platyphyllos* Scop.

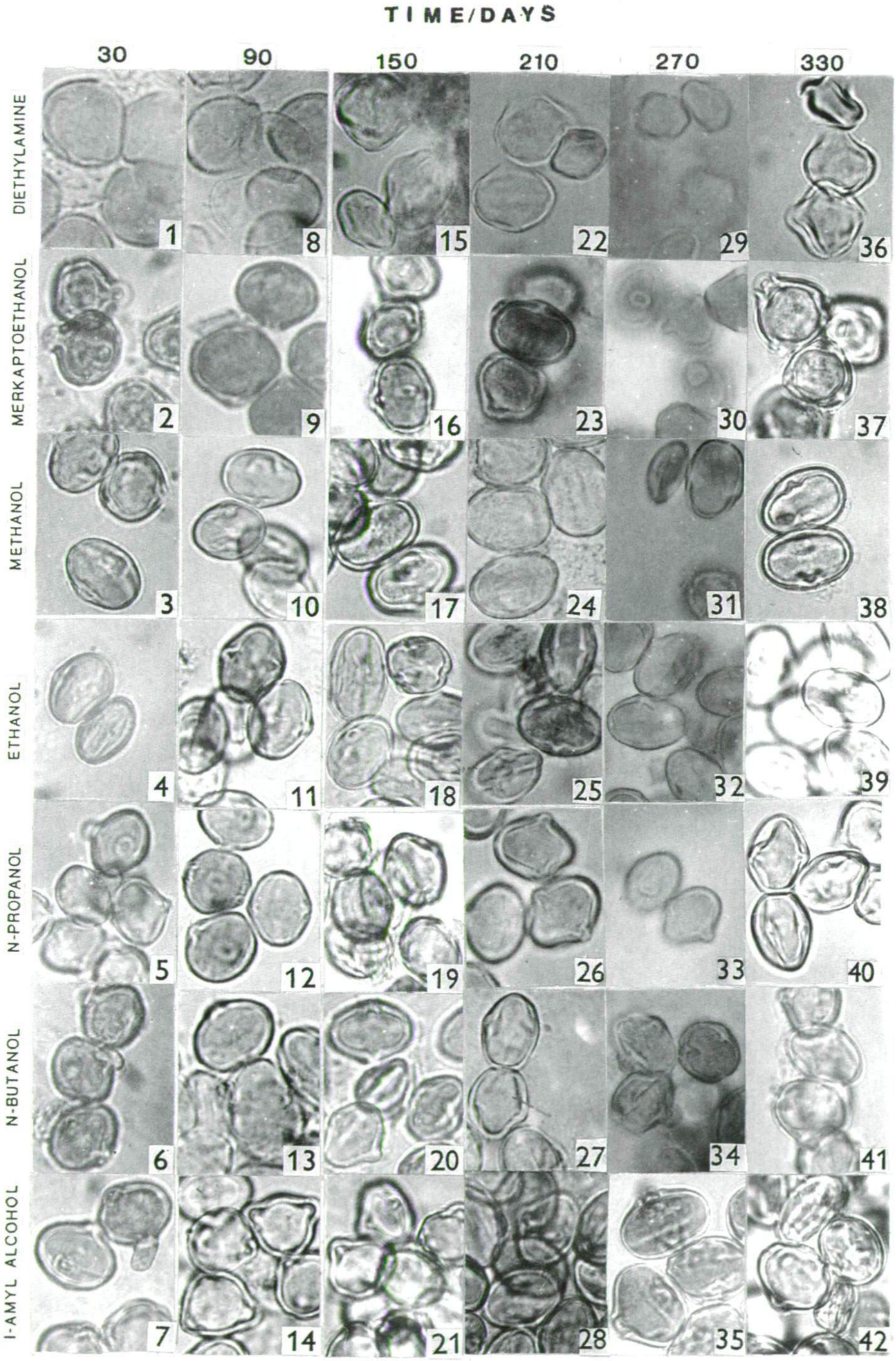

Plate 5.5., 1–42. *Castanea sativa* MILL.

1. pollen grains without pollen tube (Plate 5.4., fig 16)
2. the pollen tube developed at one or two aperture (Plate 5.4., fig. 3)
3. the pollen tube appeared at each apertures (Plate 5.4., fig. 18)

After 30 days the pollen tube developed in a remarkable per cent as the result of the dissolution effect of the solvents as follows. N-propanol, n-butanol and i-amyl alcohol. Merkaptoethanol was effectual after 330 days.

Castanea sativa MILL. (Plate 5.5., figs. 1–42)

Pollen grains of this species are resistant to the used organic solvents. Thinning of the exine (Plate 5.5., fig 1) and protrusions in the apertural area were observed only (Plate 5.5., fig. 5)

Discussion and Conclusions

1. Diethylamine dissolved relatively quickly the ectexine of the pollen grains of *Tilia platyphyllos* and *Platanus hybrida*. In our previous paper (KEDVES and GÁSPÁR 1994, 1995) we pointed out this phenomenon at the exospore of *Equisetum arvense* and at the exine of the genus *Quercus*. In this point of view the resistant exine of the pollen grains of *Castanea sativa* is worth of mentioning. Dissolutions experiments of further *Fagaceae* pollen grains (*Fagus, Pasania, Nothofagus*) seem to be necessary.
2. Alterations of the diameter not included originally within this research program. Previously we observed that there are important changes, we believe, that the presented results of *Platanus hybrida* are worth of mentioning.
3. Pollen tube development was investigated in our Laboratory in the first place after X-ray irradiation. This phenomenon may happen in consequence of other experimental influences.

Acknowledgements

This work was supported by the Grant OTKA 1/7, T 014692. We would like to express sincere thanks to Miss Á. ERDŐDI and Miss. V. KECSKEMÉTI for their kind assistance in the preparation of the manuscript.

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	30			90			150			210			270			330			days
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
diethylamine	76.5	22.5	1.0	68.5	16.5	15.0	53.0	29.5	17.5	54.0	32.0	14.0	54.0	27.5	18.5	49.0	32.0	19.0	%
merkaptoethanol	89.0	11.0	0.0	70.5	19.0	10.5	70.5	20.0	9.5	68.5	16.0	15.5	71.5	11.5	17.0	52.5	27.0	20.5	%
methanol	91.5	7.0	1.5	83.0	13.5	3.5	68.0	27.5	4.5	79.0	17.5	3.5	84.5	13.0	2.5	73.5	17.5	9.0	%
ethanol	84.5	15.5	0.0	72.0	23.5	4.5	77.0	22.0	1.0	70.0	22.5	7.5	73.0	22.0	5.0	75.0	19.0	6.0	%
n-propanol	89.0	10.0	1.0	84.0	13.0	3.0	76.0	19.5	4.5	84.0	14.0	2.0	71.5	22.0	6.5	88.5	8.0	3.5	%
n-butanol	89.5	10.0	0.5	67.0	24.0	9.0	75.0	21.5	3.5	69.5	17.0	13.5	50.5	36.5	13.0	25.5	53.5	21.0	%
i-amyl alcohol	74.5	12.5	13.0	49.0	28.5	22.5	65.0	24.5	10.5	60.0	31.5	8.5	56.5	25.5	18.0	29.5	41.5	29.0	%

Larix decidua MILL.
Table 5.1.

	30 days		90 days		150 days		210 days		270 days		330 days		standard		average
diethylamine	1.50%	15 µm											8.00%	15 µm	
	22.0%	17.5 µm											65.00%	17.5 µm	
	33.50%	20 µm											25.50%	20 µm	16.67%
	27.50%	22.5 µm											1.15%	25 µm	
	13.0%	25 µm													
	2.50%	27.5 µm													
merkaptoethanol	1.00%	12.5 µm	19.00%	15 µm	4.00%	12.5µm	5.00%	12.5 µm	23.00%	15 µm	1.50%	15 µm	8.00%	15 µm	
	14.5%	15 µm	37.50%	17.5 µm	15.00%	15 µm	26.50%	15 µm	29.50%	17.5µm	14.50%	17.5 µm	65.00%	17.5 µm	
	31.00%	17.5 µm	32.00%	20 µm	27.00%	17.5 µm	39.00%	17.5 µm	32.00%	20 µm	28.50%	20 µm	25.50%	20 µm	18.30%
	44.50%	20 µm	10.00%	22.5 µm	28.50%	20 µm	25.50%	20 µm	13.00%	22.5 µm	26.50%	22.5 µm	1.15%	25 µm	
	8.00%	22.5 µm	1.50%	25 µm	20.50%	22.5 µm	4.00%	22.5 µm	2.50%	25 µm	20.50%	25 µm			
	1.00%	25 µm			5.00%	25 µm					0.50%	27.5 µm			
ethanol	5.00%	12.5 µm	22.00%	15 µm	26.50%	15 µm	29.00%	15 µm	16.50%	15 µm	14.00%	17.5 µm	8.00%	15 µm	
	22.00%	15 µm	45.50%	17.5 µm	48.50%	17.5 µm	41.00%	17.5 µm	42.50%	17.5 µm	48.50%	20 µm	65.00%	17.5 µm	
	55.00%	17.5 µm	25.00%	20 µm	23.50%	20 µm	26.50%	20 µm	32.00%	20 µm	32.50%	22.5 µm	25.50%	20 µm	20.39%
	22.00%	20 µm	7.50%	22.5 µm	1.50%	22.5 µm	3.50%	22.5 µm	8.00%	22.5 µm	5.00%	25 µm	1.15%	25 µm	
	5.00%	22.5 µm							1.00%	25 µm					
methanol	3.50%	15 µm	3.00%	15 µm	20.50%	15 µm	2.00%	15 µm	13.50%	15 µm	10.00%	15 µm	8.00%	15 µm	
	38.50%	17.5 µm	29.00%	17.5 µm	44.00%	17.5 µm	21.00%	17.5 µm	40.50%	17.5 µm	44.00%	17.5 µm	65.00%	17.5 µm	
	53.00%	20 µm	30.00%	20 µm	25.00%	20 µm	58.50%	20 µm	33.50%	20 µm	37.00%	20 µm	25.50%	20 µm	
	5.00%	22.5 µm	24.50%	22.5 µm	10.50%	22.5 µm	17.50%	22.5 µm	3.50%	22.5 µm	6.00%	22.5 µm	1.15%	25 µm	20.66%
			12.00%	25 µm			1.00%	25 µm	3.00%	25 µm	3.00%	25 µm			
			1.50%	27.5 µm											
n-propanol	1.00%	12.5 µm	5.00%	12.5 µm	11.00%	15 µm	13.00%	15 µm	17.00%	15 µm	9.00%	15 µm	8.00%	15 µm	
	8.00%	15 µm	11.00%	15 µm	53.50%	17.5 µm	33.50%	17.5 µm	33.00%	17.5 µm	43.00%	17.5 µm	65.00%	17.5 µm	
	41.00%	17.5 µm	37.00%	17.5 µm	34.50%	20 µm	34.00%	20 µm	34.00%	20 µm	37.00%	20 µm	25.50%	20 µm	
	46.50%	20 µm	41.50%	20 µm	1.00%	22.5 µm	15.00%	22.5 µm	12.00%	22.5 µm	9.00%	22.5 µm	1.15%	25 µm	21.93%
	3.50%	22.5 µm	10.00%	22.5 µm			4.20%	25 µm	3.00%	25 µm	2.00%	25 µm			
									0.50%	27.5 µm					
									0.50%	32.5 µm					

	30 days		90 days		150 days		210 days		270 days		330 days		standard		average
n-butanol	3.50%	15 µm	25.00%	15 µm	5.00%	15 µm	0.30%	15 µm	13.50%	15 µm	0.80%	15 µm	8.00%	15 µm	
	39.50%	17.5 µm	42.00%	17.5 µm	11.50%	17.5 µm	31.50%	17.5 µm	48.00%	17.5 µm	29.00%	17.5 µm	65.00%	17.5 µm	
	53.00%	20 µm	28.50%	20 µm	62.00%	20 µm	37.50%	20 µm	32.50%	20 µm	32.50%	20 µm	25.50%	20 µm	20.69%
	3.50%	22.5 µm	4.50%	22.5 µm	25.50%	22.5 µm	20.50%	22.5 µm	0.60%	22.5 µm	20.50%	22.5 µm	1.15%	25 µm	
	0.50%	27.5 µm			5.00%	25 µm	7.50%	25 µm			0.80%	25 µm			
											0.20%	27.5 µm			
i-pentanol	1.50%	15 µm	15.00%	15 µm	14.50%	15 µm	3.00%	15 µm	0.50%	12.5 µm	0.15%	12.5 µm	8.00%	15 µm	
	27.50%	17.5 µm	24.50%	17.5 µm	31.00%	17.5 µm	44.50%	17.5 µm	14.00%	15 µm	13.00%	15 µm	65.00%	17.5 µm	
	59.00%	20 µm	37.50%	20 µm	48.50%	20 µm	42.00%	20 µm	34.00%	17.5 µm	28.50%	17.5 µm	25.50%	20 µm	19.93%
	12.00%	22.5 µm	19.50%	22.5 µm	6.00%	22.5 µm	9.50%	22.5 µm	41.50%	20 µm	27.50%	20 µm	1.15%	25 µm	
			4.00%	25 µm			0.10%	25 µm	0.90%	22.5 µm	20.50%	22.5 µm			
									0.10%	25 µm	9.00%	25 µm			
50% glycerine	11.50%	15 µm	0.50%	15 µm	3.00%	15 µm	24.50%	15 µm	11.00%	15 µm	20.50%	15 µm	8.00%	15 µm	
	24.00%	17.5 µm	28.50%	17.5 µm	24.50%	17.5 µm	52.00%	17.5 µm	45.00%	17.5 µm	39.50%	17.5 µm	65.00%	17.5 µm	
	34.50%	20 µm	38.00%	20 µm	50.50%	20 µm	22.00%	20 µm	40.50%	20 µm	25.50%	20 µm	25.50%	20 µm	20.53%
	11.50%	22.5 µm	20.00%	22.5 µm	19.50%	22.5 µm	15.00%	22.5 µm	3.50%	22.5 µm	11.50%	22.5 µm	1.15%	25 µm	
	5.00%	25 µm	7.50%	25 µm	2.50%	25 µm					0.30%	25 µm			
			1.00%	27.5 µm											

Platanus hybrida BROT.
Table 5.2.
Compiled by V. KECSKEMÉTI

	30			90			150			210			270			330			days
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
diethylamine	99.0	1.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	%
merkaptoethanol	87.5	9.0	3.5	88.0	12.0	0.0	85.5	12.5	2.0	97.0	3.0	0.0	92.0	7.5	0.5	54.5	37.5	8	%
methanol	85.5	12.0	2.5	99.5	0.5	0.0	87.5	11.5	1.0	98.0	2.0	0.0	93.5	5.5	1.0	85.0	14.0	1	%
ethanol	87.5	10.0	2.5	90.5	9.5	0.0	90.5	9.5	0.0	79.0	19.5	1.5	90.5	7.5	2.0	79.0	16.5	4.5	%
n-propanol	56.5	34.5	9.0	60.0	35.5	4.5	24.0	56.0	20.0	90.5	9.0	0.5	45.0	37.0	18.0	51.0	32.5	16.5	%
n-butanol	54.5	32.0	13.5	44.5	30.5	25	43.0	46.0	11.0	89.0	9.5	1.5	40.5	41.0	18.5	39	39.5	21.5	%
i-pentanol	70.5	27.5	2.0	88.5	10.5	1.0	90.0	8.5	1.5	97.0	3.0	0.0	86.0	14.0	0.0	89	10.5	0.5	%

Tilia platyphyllos SCOP.
Table 5.3.

6. X-RAY EFFECT ON THE LM MORPHOLOGY OF SOME ANGIOSPERM POLLEN GRAINS II.

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Abstract

The results of the X-ray induced morphological alterations in the LM morphology of the following species are presented in this paper: *Knautia drymeia* HEUFF., *Tilia cordata* MILL., *Elaeagnus angustifolia* L., *Hibiscus rosa-sinensis* L., *Opuntia grandis* PFEIFF. The samples selected for investigations are different in taxonomical and ecological points of view. Irradiation induced pollen tube developments were observed only without further morphological alterations. The pollen grains of *Hibiscus rosa-sinensis* and *Elaeagnus angustifolia* are the most resistant among the species presented herein.

Key words: Palynology, angiosperms, X-ray effect, light microscopy.

Introduction

The pollen grains investigated are heterogeneous in morphological and ecological points of view. Pollen grains of *Knautia drymeia* have three occasionally four apertures (pores, cf. LAVRENTIADES, 1965) of brevaxonate type. The similarly brevaxonate but brevicolpate *Elaeagnus angustifolia* pollen grains have several, early *Normapolles* characteristic features, particularly based on the TEM data (cf. KEDVES and PÁRDUTZ, 1982). As regards the pollen grains of the *Tilia* genus the short colpi and the characteristic centripetal endannulus may be pointed out (CHAMBERS and GODWIN, 1961). The investigated *Malvaceae* and *Cactaceae* pollen grains are isodiametric, periporate. TSUKADA (1964), p. 45: „La troisième par son pollen périporé et son exine réticulée (*Opuntia*) constituerait le groupe le plus évoluée." *Hibiscus rosa-sinensis* pollen grains are ornamented with characteristic echinate sculptural elements, pantoporate and spinolous following SAAD (1960).

Materials and Methods

Data of the investigated pollen grains are as follows.

Knautia drymeia HEUFF.

Locality: Botanical Garden of the J. A. University, Collected: I. GÁSPÁR, on 27.05.1995. Irradiation: on the 07.06.1995, LM investigation: on the 07.06.1995.

Tilia cordata MILL.

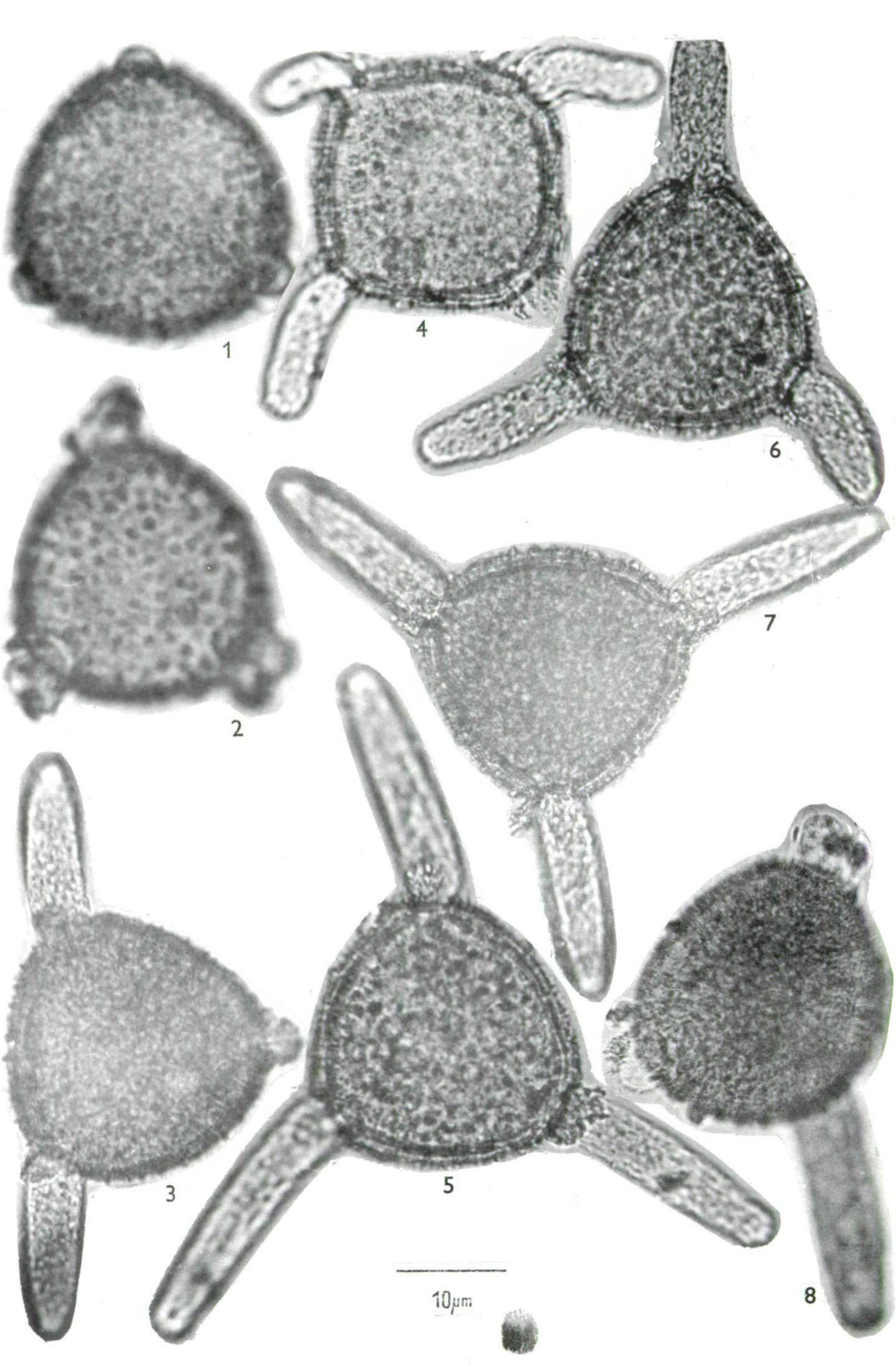

Plate 6.1.

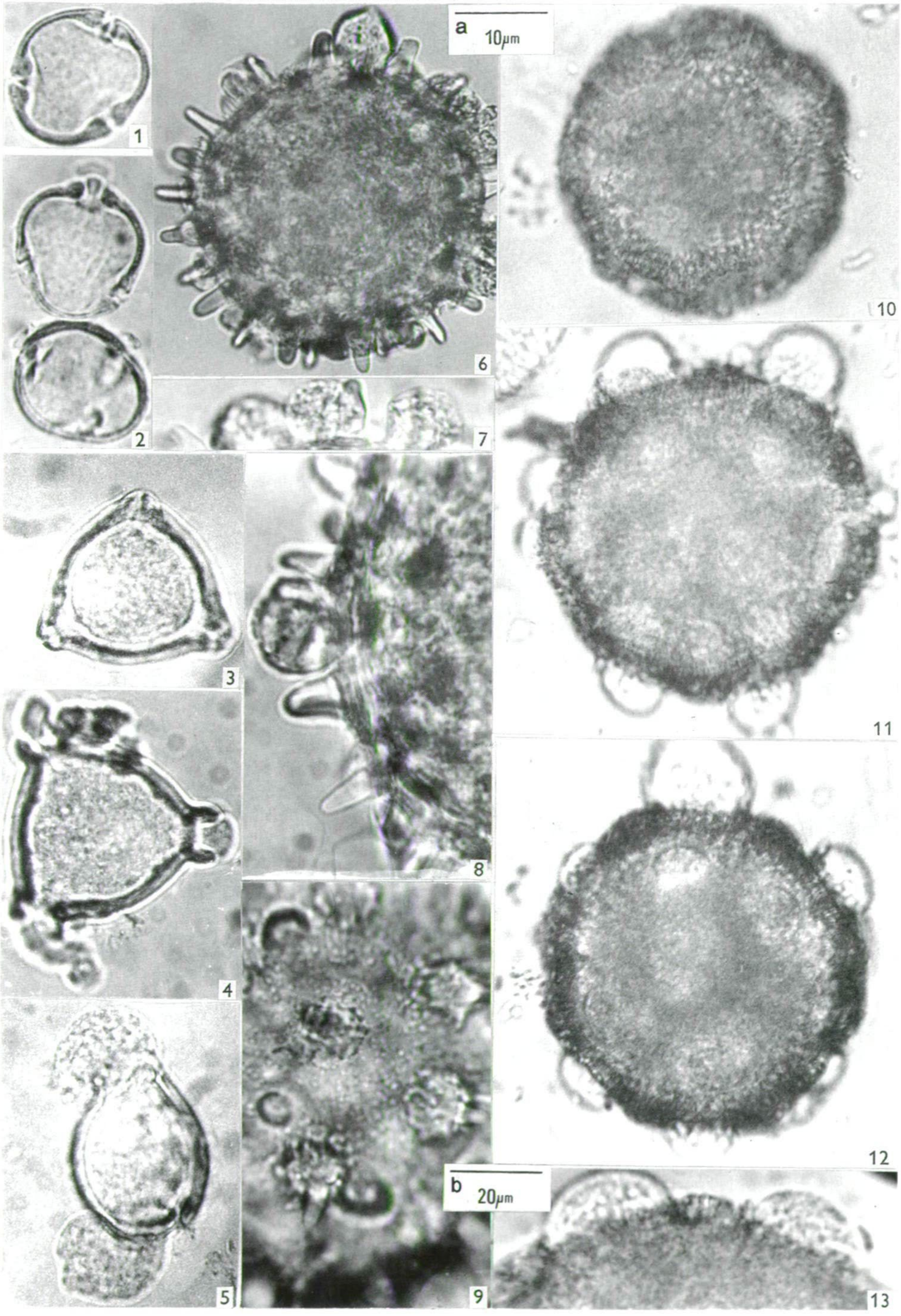

Plate 6.2.

Locality: Garden of the J. A. University. Collected: Á. KÁROSSY, on 12.06.1995. Irradiation: on the 13.06.1995, LM investigation: on the 30.06.1995.

Elaeagnus angustifolia L.

Locality: Botanical Garden of the J. A. University. Collected: Á. KÁROSSY, on 24.05.1995. Irradiation: on the 31.05.1995, LM investigation: on the 04.06.1995.

Hibiscus rosa-sinensis L.

Locality: Botanical Garden of the J. A. University. Collected: Á. KÁROSSY, on 24.05.1995. Irradiation: on the 07.06.1995, LM investigation: on the 10.06.1995.

Opuntia grandis PFEIFF.

Locality: Botanical Garden of the J. A. University. Collected: Á. KÁROSSY, on 15.06.1995. Irradiation: on the 30.06.1995, LM investigation: on the 30.06.1995.

Irradiations of the pollen grains were made with a BRON-OM1 apparatus in the Radiological Laboratory of the Department of Mineralogy, Petrography and Geochemistry of the J. A. University, Szeged. Radiation data: 35 KV, 20 mA, CuK_{α} beam. Length of irradiations: 35'.

Results

Knautia drymeia HEUFF. (Plate 6.1., figs. 1–8)

Very characteristic and long pollen tube development (Plate 6.1., figs. 5–7) were observed at 29.0%. Long and short pollen tube appeared on the same pollen grain after irradiation at 10.0% of the pollen grains (Plate 6.1., figs. 3,4,8). 56.0% of the pollen grains are non-altered (Plate 6.1., fig. 1).

Tilia cordata MILL. (Plate 6.2., figs. 1,2)

49.5% of the pollen grains are non-altered after irradiation (Plate 6.2., fig. 1). Small pollen tubes appeared at 48.0% (Plate 6.2., fig. 2), and only 2.5% are with relatively large pollen tubes.

Elaeagnus angustifolia L. (Plate 6.2., figs. 3–5)

94.5% of the irradiated pollen grains are non-altered (Plate 6.2., fig. 3). Partial pollen tube development appeared at 3.0% after irradiation (Plate 6.2., fig. 4). Characteristic and total pollen tubes were observed at 2.5% of the investigated material (Plate 6.2., fig. 5).

Hibiscus rosa-sinensis L. (Plate 6.2., figs. 6–9)

There are yellow drops superior to the pore, in all probability of protective function. 92.0% of the pollen grains are non-altered (Plate 6.2., fig. 9). Partial pollen tube development was observed at 9.0% of the investigation material (Plate 6.2., figs. 6–8).

Opuntia grandis PFEIFF. (Plate 6.2., figs. 10–13)

52.5% of the irradiated pollen grains are non-altered (Plate 6.2., fig. 10). Partial or more or less total pollen tube development was observed at 47.5% of the investigated pollen grains. The observed pollen tubes are characteristic (Plate 6.2., figs. 10–13).

Plate 6.1.

1–8. *Knautia drymeia* HEUFF., Recent, Experiment No: 1/7-193.

Plate 6.2.

1,2. *Tilia cordata* MILL., Recent, Experiment No: 1/7-246.
3–5. *Elaeagnus angustifolia* L., Recent, Experiment No: 1/7-175.
6–9. *Hibiscus rosa-sinensis* L., Recent, Experiment No: 1/7-197.
10–13. *Opuntia grandis* PFEIFF., Recent, Experiment No: 1/7-252. Magnifications: Figs. 6. 10–12; scale "a", figs. 1–5, 7–9, 13; scale "b".

Discussion and Conclusions

Based on our new data we can come to the conclusions as follows:

1. More or less characteristic and intensive pollen tube development was observed at all species investigated after X-ray irradiation.
2. In comparison with our previous results on *angiosperm* pollen grains the peculiar pollen tube of *Knautia drymeia* suggests the necessity of further investigations on this genus or on the species of this family. The partial dissolution method may be succesful not only with the LM, but with the TEM method, too.
3. Pollen tube development was observed on the genus *Tilia* after 30 days of dissolution with different organic solvents (ethanol, n-propanol, n-butanol and i-amyl alcohol, cf. KEDVES et al., 1998).
4. The resistance of the pollen grains of *Elaeagnus angustifolia* is also interesting.
5. The *Malvaceae* pollen grains seem to be also important objects for experimental palynology methods on LM and TEM level.

Acknowledgements

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7. X-RAY EFFECT ON THE ULTRASTRUCTURE OF THE POLLEN GRAINS OF PINUS GRIFFITHII McCLELL.

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Abstract

The transmission electronmicroscopical results of X-ray irradiated pollen grains of *Pinus griffithii* McCLELL pollen grains are presented in this paper. Irradiation with CuKα X-ray, at 35 KV, 20 mA, during 5', 15' 35' and 60'. The sporopollenin biopolymer system is resistant to irradiation similarly to that of *Ginkgo biloba* L. Subunits were not observed in contrast to the partial dissolutions method. But after 60' of irradiation molecular structures (sensu strictu) were observed in particular at the endexine/intine border. Microbial organisms were observed not only on the surface of the pollen grains, but within the ectexine, in the cavities of the infratectal layer, mostly in the alveolar system of the bladders.

Key words: Palynology, recent, *Pinus griffithii*, X-ray effect, TEM.

Introduction

Pollen grains of *Pinus griffithii* McCLELL are very important in one of the research programs of our Laboratory. The quasi-crystalloid basic biopolymer skeleton was first discovered in the partially degraded pollen grains of this species (KEDVES 1988a,b). Later (KEDVES, 1989a) the first method of investigation of the biopolymer symmetry of the metastable skeleton was published, and in another paper (KEDVES 1989b) three degrees have been distinguished at the highly organized biopolymer units of the sporoderm. Symmetry operations of the biopolymer structure in angstroem dimension were published in several papers on the partially degraded pollen grains of *Pinus griffithii* McCLELL (KEDVES, KINCSEK, AMBRUS, FEJES and GYEBROVSZKI 1990, KEDVES 1990, 1991, KEDVES, PÁRDUTZ, FARKAS and VÉR 1991, KEDVES, TÓTH, FARKAS, BELLON and SCHMÉL 1992, KEDVES, TÓTH and GOTTL, 1994). In 1993, KEDVES, TÓTH and FARKAS published the first rotation results in a pentagonal molecule of *Pinus griffithii* exine. The symmetry operations verified that the quasi-crystalloid skeleton or lattice is present in the biopolymer system on molecular level, too. To the stabilizing biopolymer system of the metastable quasi-crystalloid skeleton the first TEM data were published by KEDVES and TÓTH (1994). Further molecular structures of the partially dissolved foot layer and endexine were described by KEDVES, TÓTH, KÁROSSY and VARGA (1996).

Further data concerning the experimental results on *Pinus griffithii* pollen grains were published by KEDVES and PÁRDUTZ (1992) and KEDVES and GÁSPÁR (1994).

Till this time we have TEM data of the X-ray irradiated pollen grains of the following species: *Alnus glutinosa* (L.) GAERTN. (KEDVES and PÁRDUTZ, 1992), *Ginkgo biloba* L.

(KEDVES and PÁRDUTZ, 1997), *Ustilago maydis* (DE CANDOLLE) CORDA (KEDVES, PÁRDUTZ and BORBOLA, 1997).

LM data of the X-ray irradiated *Pinus griffithii* pollen grains were published by KEDVES and GÁSPÁR (1995a,b).

The aim of this paper to get comparative TEM data of the X-ray irradiated *Pinus griffithii* pollen grains. Our paper (KEDVES, HEGEDŰS and OLÁH, 1992) was used to the terminology of the LM morphology of the bisaccate *gymnosperm* pollen grains.

Materials and Methods

The investigation material was collected in the Botanical Garden of the J. A. University 16.05.1990, by I. OLÁH and A. HEGEDŰS. After collection the pollen grains were frozen at –20 °C to diminish the alterations of the biopolymer system. The irradiations were made 05.08.1993, with a BRON-OM1 apparatus in the Radiological Laboratory of the Department of Mineralogy, Petrology and Geochemistry of the J. A. University, Szeged. Radiaton data: 35 KV, 20 mA, CuKα beam. Length of time and numbers of experiments: 5' 1736, 15' 1737, 35' 1738, 60' 1739. After irradiation the pollen material was postfixed with 1.0% OsO_4 aquous dilution and embedded in Araldite. The ultrathin sections were made at the Hungarian Academy of Sciences Biological Research Center EM Laboratory on a Porter Blum ultramicrotome. The TEM photographs were taken on an Opton EM-902 (resolution 2–3 Å), and on a Tesla BS-540 (resolution 5 Å).

Results

The ultrastructure of the non-experimental fresh pollen grains was described previously (KEDVES 1989, planche 1, 1,2). Beneath the foot layer it is a thin endexine which seems to be non-structured.

Experiment No: 1736 (Plate 7.1., figs. 1,2). – Alterations were not observed in the fine structure of the outer part of the bladders (Plate 7.1., fig. 1). The ultrastructure of the exine of the corpus was investigated on semi-tangential sections (Plate 7.1., fig. 2). Similarly to the bladders the substance of the exine was not altered.

Experiment No: 1737 (Plate 7.1., figs. 3–5). The fine structure of the exine of the corpus is not altered. The ultrastructure of the foot layer and the endexine is very similar to that of the non-experimental pollen grains. No alterations were observed in the fine structure of the bladders (Plate 7.1., fig. 4). At the proximity of the corpus/bladder border, the foot layer separated from the endexine, and the endexine is lamellar.

Experiment No: 1738 (Plate 7.2., figs. 1–4). – No important alterations were observed in the ultrastructure of the exine of the corpus (Plate 7.2., figs. 1,2). The endexine is separated from the foot layer, which is more or less homogeneous. Sometimes the electron density of the endexine is strong (Plate 7.2., fig. 2). The ultrastructure of the endexine at the corpus/saccus border is also homogeneous, the ectexine is without alterations. Within the holes of the alveolar system of the bladders microbial organisms were observed (Plate 7.2., fig. 3).

Experiment No: 1739 (Plate 7.3., figs. 1,2, plate 7.4., 7.5.). – The exine surface in the germinal area (Plate 7.3., figs. 1, 2) is full of microorganisms. The ectexine, including the foot layer disappears in the apertural area. The endexine is homogeneous, its electron density is strong. In the highly magnified pictures of the ectexine (Plate 7.4., figs. 1,2,

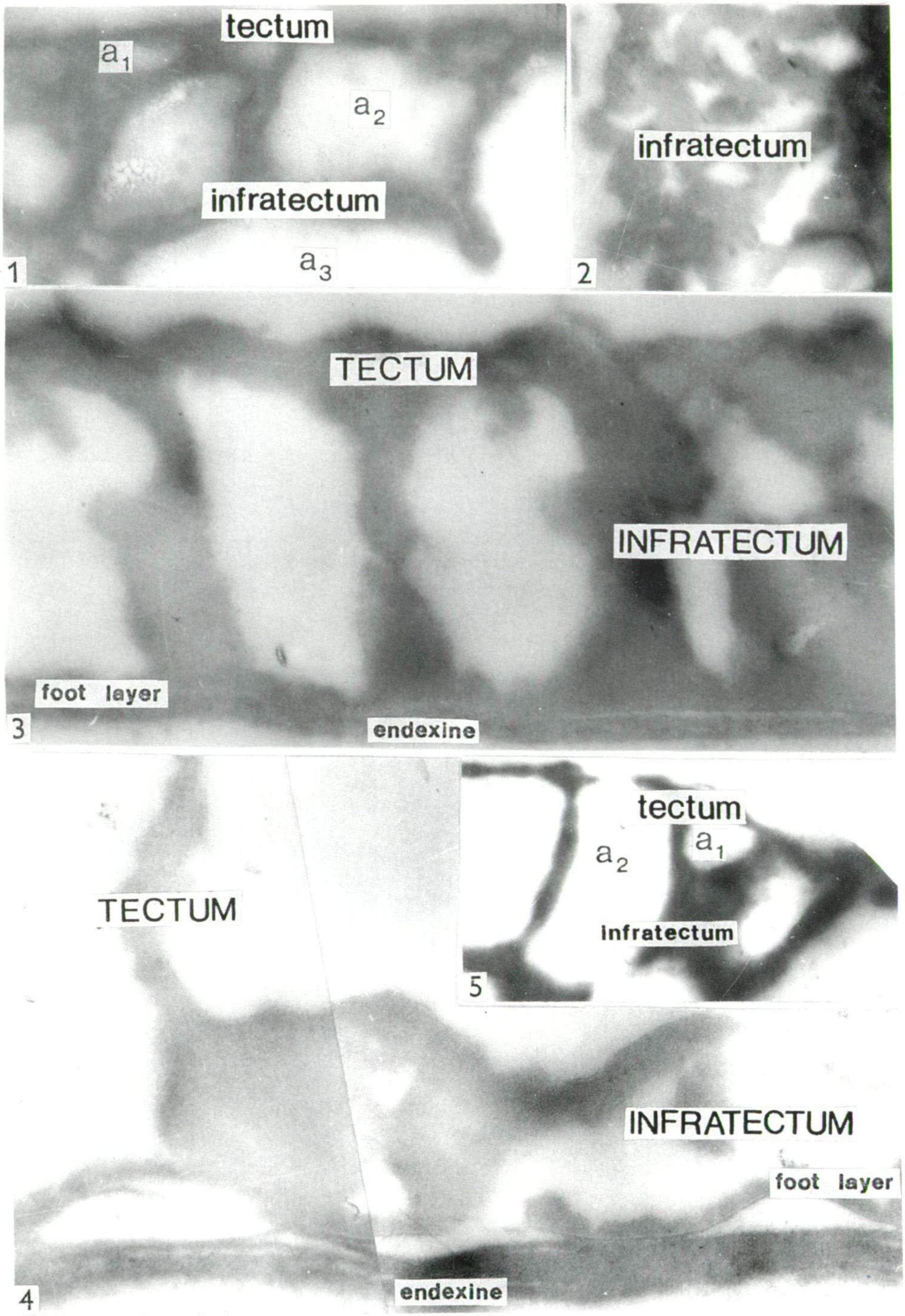
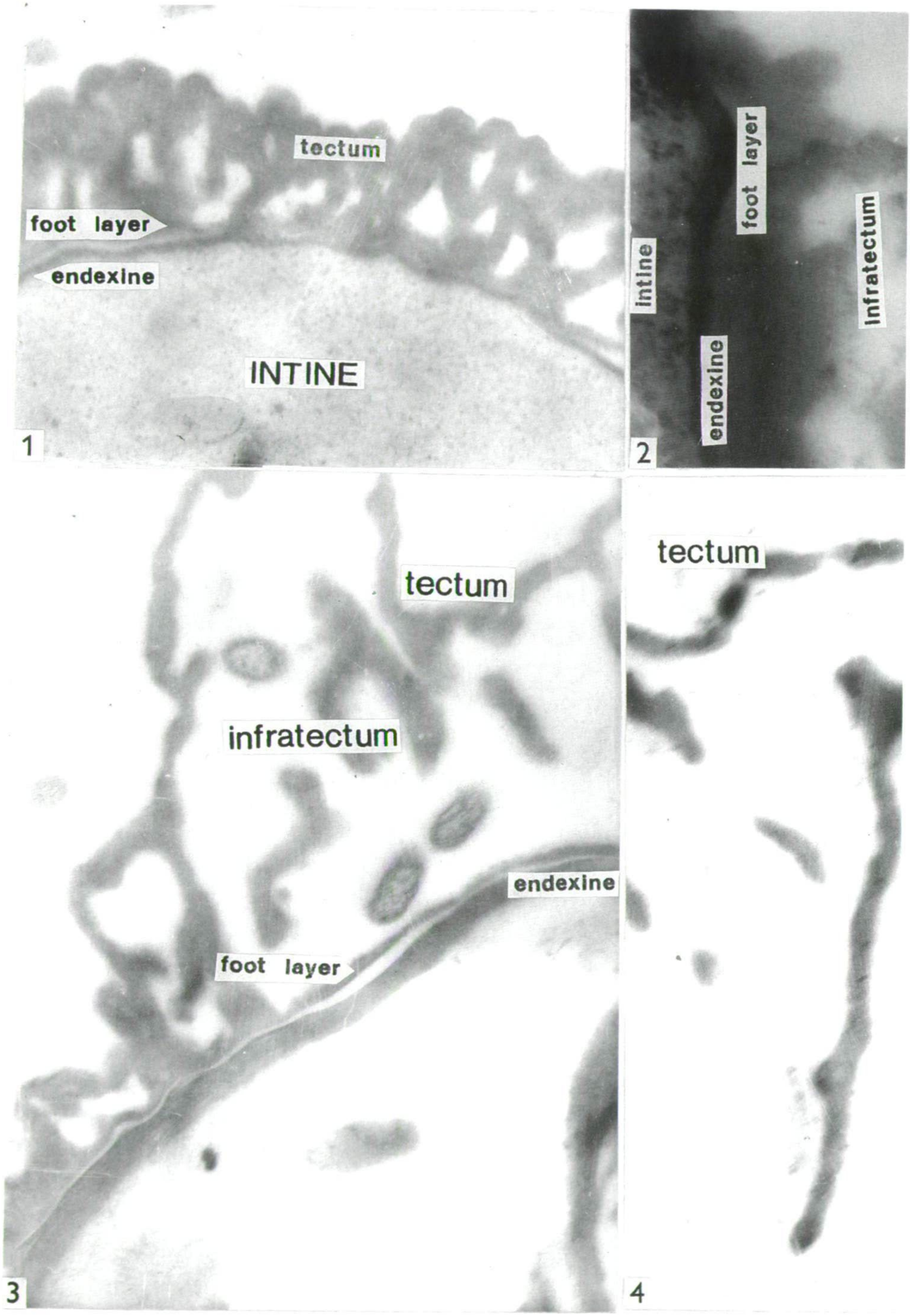
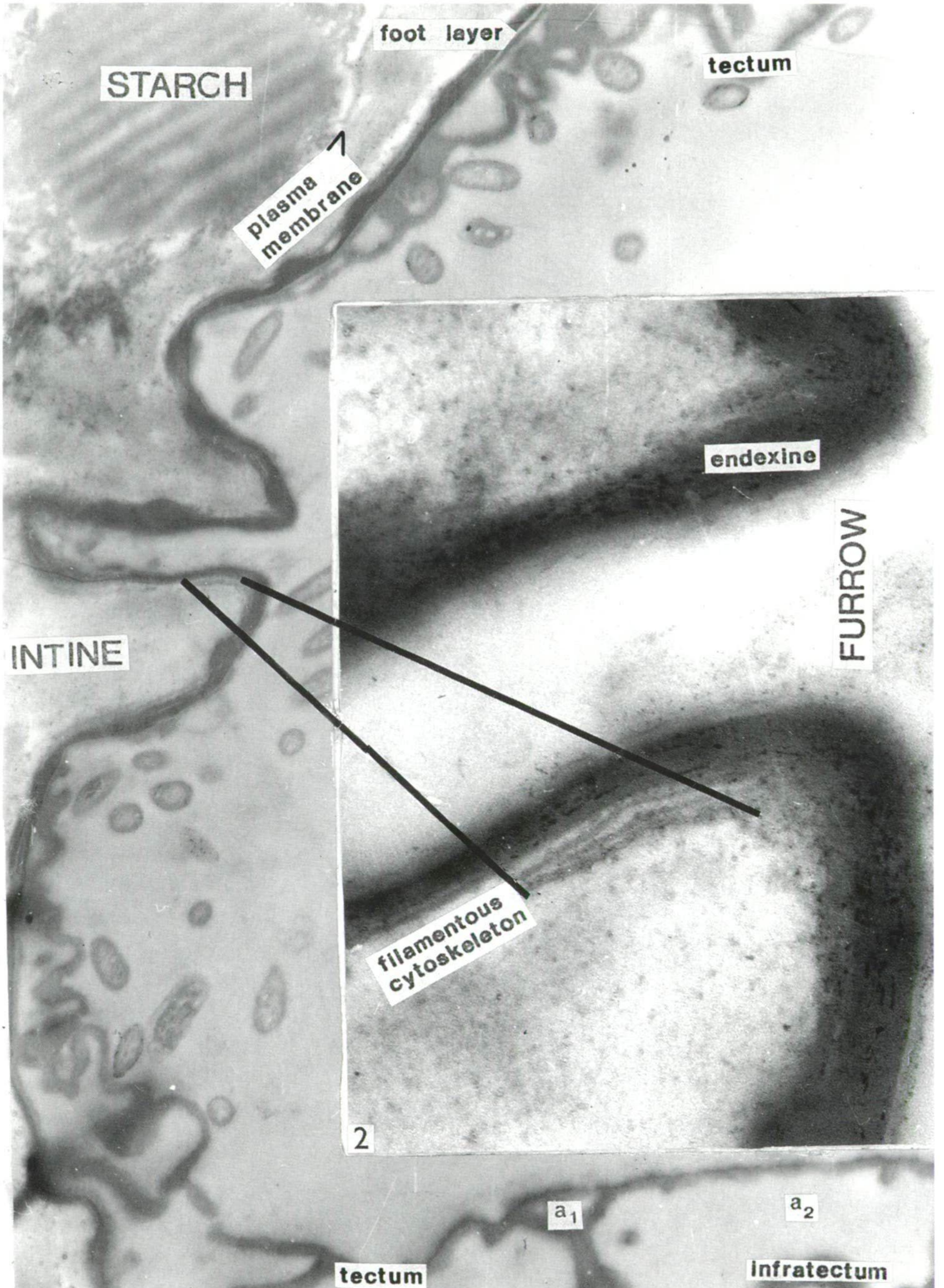

tectum
a1
a2
infratectum
a3
1
infratectum
2
TECTUM
INFRATECTUM
foot layer
3
endexine
tectum
a1
a2
infratectum
5
TECTUM
INFRATECTUM
foot layer
4
endexine

Plate 7.1.



tectum
foot layer
endexine
INTINE
1
intine
foot layer
endexine
infratectum
2
tectum
infratectum
endexine
foot layer
3
tectum
4

Plate 7.2.



foot layer
tectum
STARCH
plasma membrane
endexine
FURROW
INTINE
filamentous cytoskeleton
2
a1
a2
tectum
infratectum
1
S A C C U S

Plate 7.3.

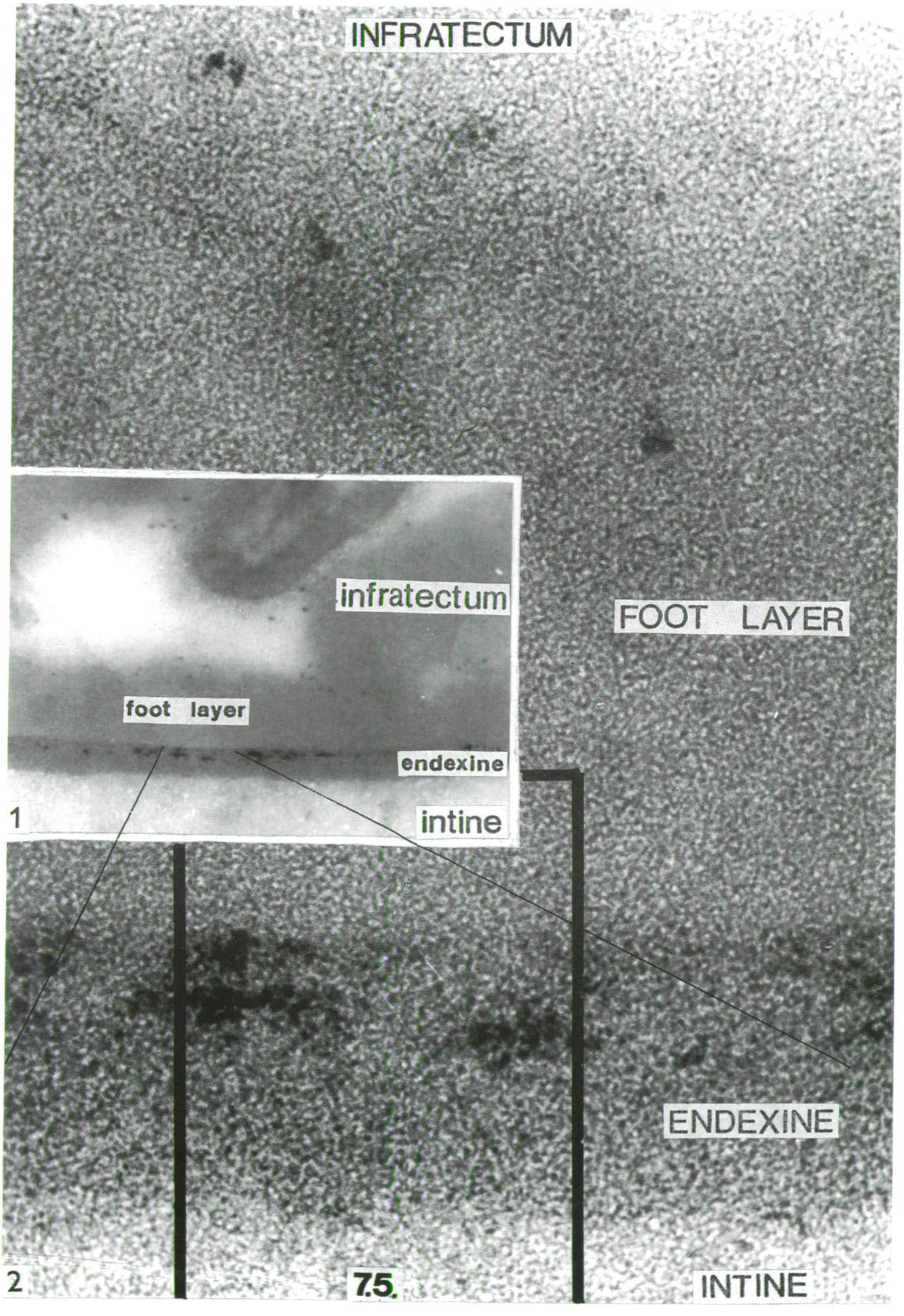

INFRATECTUM
infratectum
FOOT LAYER
foot layer
endexine
1
intine
ENDEXINE
2
7.5.
INTINE

Plate 7.4.

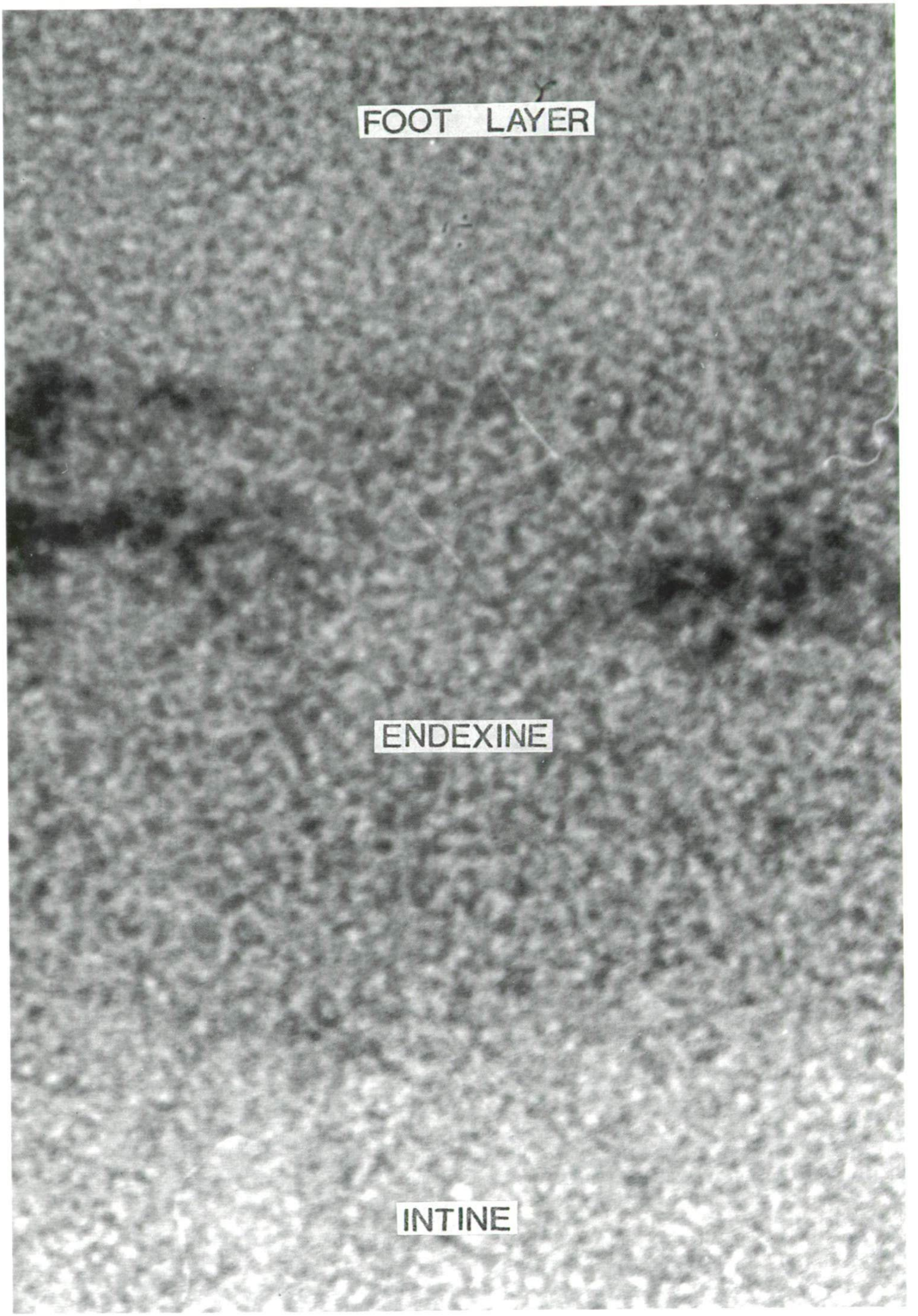


Plate 7.5.

plate 7.5.) of the corpus, remarkable desintegration was observed. Within the endexine there are granular particles with high electron density. The molecular system is very complex (Plate 7.5.) and based on our up-to-date knowledge we can establish the following:

1. The bordering lines of the different layers of the exine (ectexine, endexine, intine) in the highly magnified pictures become continuously less characteristic.
2. A trend toward a homogeneous molecular system may be established. Well shown is in Plate 7.5. that the differences between foot layer and endexine newly disappear. The lamellae are represented by unit-membrane like remnants only. The intine differs from the endexine by its electron density.
3. Chain molecular systems were observed in different orientation. Cyclic molecular structures were also observed in the highly magnified pictures (Plate 7.5.).

Plate 7.1.

1–5. *Pinus griffithii* McCLELL. Recent.
1,2. Experiment No: 1736.
1. Detail of the ectexine ultrastructure of the saccus. Negative no: 6068. 15.000x.
2. Detail of the infratectum. Negative no: 6062. 15.000x.
3–5. Experiment No: 1737.
3. Ultrastructure of the exine of the corpus. Negative no: 6063. 50.000x.
4. Exine ultrastructure of the corpus/saccus border. Negative no: 6065, 6066. 50.000x.
5. Detail of the ectexine ultrastructure of the saccus. Negative no: 6043. 15.000x.

Plate 7.2.

1–4. *Pinus griffithii* McCLELL. Recent. Experiment No: 1738.
1. Exine ultrastructure of the corpus. Negative no: 6059. 15.000x.
2. Detail of the exine ultrastructure of the corpus. Negative no: 6056. 50.000x.
3. Exine ultrastructure of the corpus/saccus border. Negative no: 6057. 15.000x.
4. Detail of the exine ultrastructure of the saccus. Negative no: 6053. 15.000x.

Plate 7.3.

1,2. *Pinus griffithii* McCLELL. Recent. Experiment No: 1739.
1. Ultrastructure in the apertural area. Negative no: 1082. 8.000x.
2. Detail of the ultrastructure in the furrow area. Negative no: 6081. 50.000x.

Plate 7.4.

1,2. *Pinus griffithii* McCLELL. Recent. Experiment No: 1739.
1. Detail of the exine ultrastructure of the corpus. Negative no: 4954. 100.000x.
2. Highly magnified picture of the foot layer, endexine and intine. Negative no: 4955. 1,000.000x.

Plate 7.5.

Pinus griffithii McCLELL. Recent. Experiment No: 1739. Molecular structure of the foot layer, endexine and intine. Negative no: 4955. 2,500.000x.

Discussion and Conclusions

The resistance of the exine layers, and in general of the whole pollen grains to X-ray irradiation of *Pinus griffithii* can be pointed out in the first place. Some organelles of the protoplasm have not altered in a remarkable manner. Filamentous cytoskeleton, the plasma membrane and starch granules have been observed in a more or less well preservation. The molecular system was not so well discovered by the X-ray irradiation as by the organic solvents. But it is worth of mentioning that the results presented in Plate 7.5. are similar to those of *Ustilago maydis* (DE CANDOLLE) CORDA, but after a stronger X-ray dose (300').

Acknowledgements

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8. LIST OF PUBLICATIONS OF THE LABORATORY UNTIL DECEMBER 1997

compiled by

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Cell Biological and Evolutionary Micropaleontological Laboratory of the Department of Botany of the J. A. University, H-6701, P. O. Box 993, Szeged, Hungary

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Chronicle

Compiled by

A. BORBOLA and Á. ERDŐDI

Visiting scientists

NURDAN YAVUZ (Middle East Technical University, Geological Engineering Department, Ankara, Turkey) visited our Laboratory for a short time (8,9, May, 1997). She was interested in different kinds of research programs of the Laboratory, especially fossil palynological investigations, and the experimental methods of the biopolymer structure of sporopollenin.

Dr. SHYAM C. SRIVASTAVA, Assistant Director and Convener-Secretary of Birbal-Savitri Sahni Foundation (Lucknow, Uttar Pradesh, India) visited our Laboratory from 21st until 26th August. He was awarded at the Laboratory meeting with the Commemorative Medal of the Laboratory (Picture 1.).

Dr. PHILIPPE MARC (Université Lyon I, Villeurbanne, France) visited the Laboratory on the 26th August. He was interested in the experimental research program of the LM and TEM investigations on the secondary wood of the Hungarian Tertiary lignites.

Dr. MADHAV KUMAR Scientist-C (Birbal Sahni Institute of Palaeobotany, Lucknow, Uttar Pradesh, India) worked in our Laboratory from 28 September to 25 October on the joint research program on the high temperature effect on recent *palm* pollen grains. A paper on the results of some recent *palm* pollen species will be completed by KEDVES, M., BORBOLA, A., S. K. M. TRIPATHI and MADHAV KUMAR.

International Laboratory activities

26 March – 1st April, 1997, Barcelona, Spain.

Prof. Dr. M. KEDVES worked with Prof. Dr. N. SOLÉ DE PORTA (Universitat de Barcelona, Departament de Geologia Dinámica, Geofisica i Paleontologia Facultad Geologia Zona Universitaria de Pedralbes, Barcelona) on a joint research program on the palynology of the *angiosperm* pollen grains of the Eocene sediments of Málaga.

08–10 June, 1997, Barcelona, Spain.

The above mentioned research program was continued, and new cooperations were elaborated.

29 August – 03 September, 1997, Lyon, France.

At the XVème Symposium A.P.L.F. (Biostratigraphique & Systématique) on the 1st September, the following oral communication was presented; KEDVES, M.: L'importance stratigraphique des pollens des *angiospermes* du Crétacé supérieur et du Tertiaire inférieur en Europe.

12–21 September, 1997, Johannesburg, South Africa.

At the 3rd Symposium of African Palynology the following oral communications were presented by Prof. Dr. M. KEDVES:

17 September, KEDVES, M. and PÁRDUTZ, Á.:

Experimental investigations on the pollen grains of *Welwitschia mirabilis* HOOK.

18 September, KEDVES, M. and MÉSZÁROS, R.:

Angiosperm phylogeny and paleophytogeography on palynological basis.

On 18th September at the "Session I. Cenozoic" Prof. Dr. M. KEDVES was the Chairman.

Hungarian scientific activities

On the 2nd March appeared the 8th number of Plant Cell Biology and Development.

At the 1322nd meeting of the Botanical Section of the Hungarian Biological Society on the 5th May the following lecture was delivered by M. KEDVES:

A kísérletes palinológia újabb eredményei (Recent results of experimental Palynology).

On the 19th November at the Scientifical Meeting of the Paleontological Commission of the Hungarian Academy of Sciences, Prof. Dr. M. KEDVES presented a paper: Fosszilis sporomorfák ultrastruktúra filogéniája (Ultrastructure phylogeny of the fossil sporomorphs).

At the 1329th meeting of the Botanical Section of the Hungarian Biological Society, on the 15th December two lectures were presented by Prof. Dr. M. KEDVES:

Beszámoló az A.P.L.F. XV. Szimpóziumáról (Lyon, 1997. szeptember 1–3),

Beszámoló a 3. AP Szimpóziumáról (Johannesburg, 1997. szeptember 7–13).

Laboratory meetings

14.02.1997.

The present day state of the 8th and 9th volumes of Plant Cell Biology and Development, speaker: M. KEDVES.

The contributions of the Laboratory at international scientific meetings of this year, speaker: M. KEDVES.

Other actual business, speaker: M. KEDVES.

07.03.1997.

The research programs of the Laboratory, speaker: M. KEDVES.

Other actual business, speaker: M. KEDVES.

11.04.1997.

Report on the recent state of the joint research program on the Eocene *angiosperm* pollen grains of Málaga, Spain, speaker: M. KEDVES.

The present day state of the publications of the Laboratory, speaker: M. KEDVES.

Other actual business, speaker: M. KEDVES.

21.08.1997.

The Commemorative Medal of the Laboratory was handed to Prof. Dr. T. SZEDERKÉNYI in the study of Prof. Dr. M. KEDVES at an exclusive reception.

22.08.1997.

On the occasion of the 7th anniversary of the Laboratory another exclusive reception was held for the members of the Laboratory. Participants: I. BAGI, A. BORBOLA, E. HORVÁTH, V. KECSKEMÉTI, A. TÓTH. Prof. Dr. M. KEDVES handed the Commemorative Medal of the Laboratory to Dr. SHYAM C. SRIVASTAVA (Lucknow, Uttar Pradesh, India), (picture 1). The Laboratory Diploma was handed to A. BORBOLA (picture 2).

05.09.1997.

Report on the XVth symposium of the A.P.L.F., speaker: M. KEDVES.

The present day state of the volumes of Plant Cell Biology and Development, speaker: M. KEDVES.

Discussion of the research programs of the Laboratory, speaker: M. KEDVES.

Picture 1., 2.


INTERNATIONAL LEADERS
IN ACHIEVEMENT

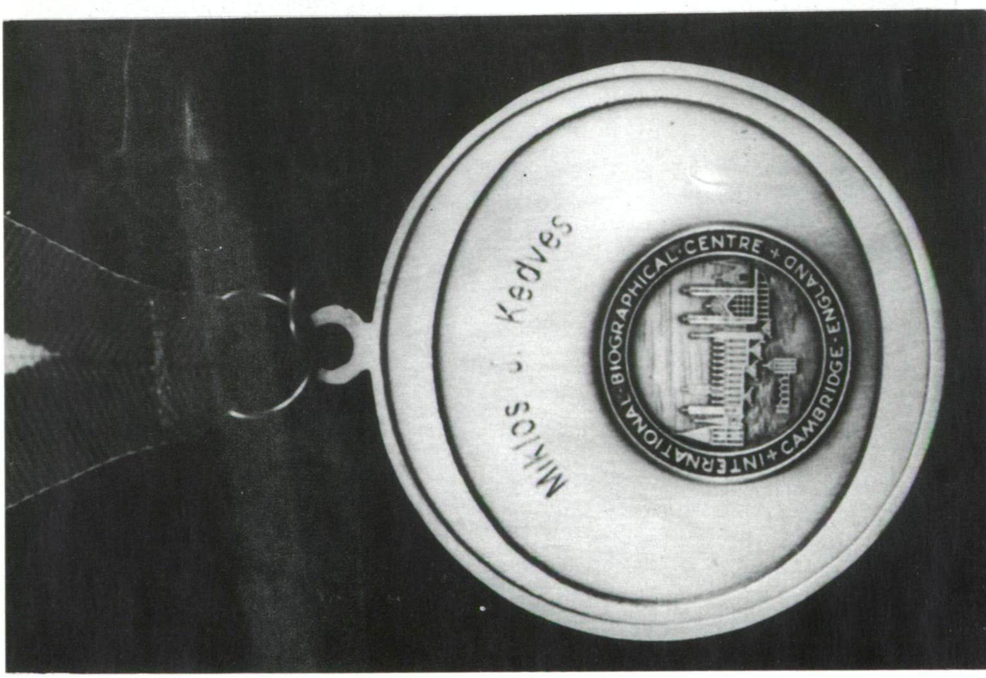
Miklos J. Kedves
INTERNATIONAL BIOGRAPHICAL CENTRE
CAMBRIDGE ENGLAND

Plate 1.

Plate 2.

26.09.1997.

Report on the 3rd Symposium of African Palynology (Johannesburg, South Africa), speaker: M. KEDVES.

Other actual business, speaker: M. KEDVES.

31.10.1997.

The actual problems of the publications of the Laboratory, speaker: M. KEDVES.

The participation of the Laboratory in international scientific meetings in 1998, speaker: M. KEDVES.

Teaching program of the Laboratory

During 1997 the following lectures were delivered:

1. Applied Palynology 2 hours, weekly.
2. Biopolymer organization and symmetry, 1+2 hours weekly.
3. Theory of Evolution and Natural Philosophy, 1 hour weekly.
4. Basic Palynology, 2+2 weekly.
5. Plant cell ultrastructure, 1 hour weekly.
6. Theory of the Supernova, 1 hour weekly.

Awards

During this year Prof. Dr. M. KEDVES was awarded with the following medals:

International Leaders in Achievement, gold medal. Donator: The International Biographical Centre, Cambridge, England (Plate 1, figs. 1,2).

International Order of Ambassadors. Donator: American Biographical Institute, Raleigh, North Carolina, U.S.A. (Plate 2).

Man of the Year 1997. Donator: American Biographical Institute, Raleigh, North Carolina, U.S.A.

Personalia

Dr. A. TÓTH started her PhD course at the Szent-Györgyi Medical University in Szeged, but she continues her researches in the Cell Biological and Evolutionary Micropaleontological Laboratory too.

Picture 1. Dr. SHYAM C. SRIVASTAVA and Prof. Dr. M. KEDVES. Awarding the Commemorative Medal of the Laboratory

Picture 2. Group of the participants of the reception of the Laboratory. From left to righ: E. HORVÁTH, Dr. SHYAM C. SRIVASTAVA, Prof. Dr. M. KEDVES, Dr. A. TÓTH and A. BORBOLA who was honoured in 1997, with the Diploma of the Laboratory. Pictures were taken by Dr. É. SIPOS-KEDVES.

Plate 1.

1,2. Both sides of the gold medal of the International Leaders in Achievement. (The International Biographical Centre, Cambridge, England). The pictures were taken by Dr. I. BAGI.

Plate 2.

Front side of the medal of the International Order of Ambassadors (American Biographical Institute, Raleigh, North Carolina, U.S.A.). The picture was taken by Dr. I. BAGI.

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